Energy Reduction Strategies for Marine Corps Base Camp Pendleton

Assessment and Recommendations

Professional Report

May 7, 2012

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This report was submitted in partial satisfaction of the requirements for the Master of Urban and Regional Planning, Department of Planning, Policy, and Design. University of California, Irvine

Abstract

The purpose of this report is to identify actions to reduce the energy consumption of existing buildings at the Marine Corps Base Camp Pendleton in California and to provide recommendations for the implementation of these actions. The assessment begins with a baseline assessment of current electrical and natural gas consumption. Energy conservation and efficiency projects are explored to identify economic approaches to minimizing Base energy demand. Renewable energy technologies are then examined for their potential for energy reduction. This assessment leads to recommendations for further energy conservation, energy efficiency measures, and renewable energy reduction projects. The assessment is designed to give MCB Camp Pendleton decision makers a clear understanding of the opportunities for energy reduction projects and the steps needed to possibly implement them. Ultimately, the detailed process in this report should lead to minimized energy demand and to the ability of Base to achieve the maximum leverage of local renewable energy resources.

Acknowledgements

The author would like to thank Robert Gilleskie and the energy team at Marine Corps Base Camp Pendleton for their cooperation and assistance in support of this report.

The author would also like to thank Professor Tim-Allen Bruckner at the University of California, Irvine for his guidance and assistance.

Finally, the author would also like to thank the following people for their assistance and guidance in editing and finalizing this report.

- Ken Chew – University of California, Irvine
- Amy Cramer – University of California, Irvine
- Juliana Zanotto – University of California, Irvine
- Bevin Harris – MCB Camp Pendleton
- David Toney – MCB Camp Pendleton
- My parents

Table of Contents:

List of Figures

List of Tables

List of Acronyms

ACEEE	American Council for an Energy Efficient Economy
AC	alternating current
AHU	air handling unit
ARRA	American Recovery and Reinvestment Act
Btu	British thermal unit
CFL	compact fluorescent lighting
CHP	combined heat and power
CNG	compressed natural gas
CAES	compressed air energy storage
COP	coefficient of performance
CO2	carbon dioxide
CSP	concentrating solar power
DC	direct current
DDC	direct digital controls
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
ECIP	Energy Conservation Investment Program
ECM	Energy Conservation Measure
EPA	U.S. Environmental Protection Agency
ESPC	energy savings performance contract
EUI	The energy use index
FFV	flex fuel vehicle
Ft2	square feet
FY	fiscal year
FEMP	Federal Energy Management Program
GHG	greenhouse gas
GIS	geographic information system
GPM	gallons per minute
GSHP	ground source heat pump
HOMER	Hybrid Optimization Modeling Tool
HRSG	heat-recovery steam generator
REO	renewable energy optimization
RE	renewable energy
SAM	Solar Advisory Model
SCF	Standard cubic feet
SES	Stirling Energy Systems
SGIP	Self Generation Incentive Program
SDG&E	San Diego Gas and Electric
TES	thermal energy storage
tCO2e	Tons of carbon dioxide equivalent
HAVC	heating, ventilating, and air conditioning
IEEE	Institute of Electrical and Electronic Engineers
IESNA	Illumination Engineering Society of North America
IHSB	Island Hot Standby
kWh	kilowatt hours
kVA	kilo volt amperes
kV	kilovolt
LCOE	levelized cost of electricity
LED	light-emitting diode
MBtu	Million British thermal units
MCAS	Marine Corps Air Station
MPR	Market Price Referent
MSW	municipal solid waste
MWh	megawatt-hours
MW	megawatt
NaS	sodium sulphur
NAVFAC	Naval Facilities Engineering Command
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Council
NEV	neighborhood electric vehicles
NiCad	nickel cadmium
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
NZEI	net zero energy military installations
O&M	operation and maintenance
OSD	Office of the Secretary of Defense
PEM	proton exchange membrane
PPA	power purchase agreement
PV	Photovoltaic
PURPA	Public Utilities Regulatory Policy Act
REC	renewable energy credit
t	tons
UPS	uninterruptible power supply
VAV	variable air volume
VRLA	valve regulated lead acid
WBCSB	World Business Council for Sustainable Development
WRI	World Resources Institute
Wh	watt-hours
W	watts

Executive Summary

The Department of Defense is the largest energy consumer in the United States. (DoD, 2011) Present energy use patterns by the DoD constrains self-sufficiency, demands enormous resources, and can put the lives of American soldiers at risk. There appears to be many opportunities to more effectively meet DoD energy needs and requirements through a combination of energy conservation measures, energy efficiency technologies, and renewable energy resources.

Marine Corps Base Camp Pendleton has long recognized the strategic importance of energy to its mission and is working to reduce energy consumption as well as to enhance energy self-sufficiency by drawing on local clean energy sources. (USMC, 2011) This report presents an assessment and planning process to assess existing buildings for energy reduction potential and provides a set of recommendations.

Buildings are responsible for the majority of the natural gas and electrical energy consumption at MCB Camp Pendleton. While new buildings are the most energy efficient, building retrofits can also save a substantial amount of energy. A typical building can be retrofitted to reduce energy consumption by 30%. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010) The Base has undertaken numerous energy efficiency projects. For example, the base has installed day-lighting and lighting controls in some of the warehouses and offices, and it enacted significant water conservation measures. Despite the MCB Camp Pendleton's past energy efficiency investments, there is still potential for the buildings at MCB Camp Pendleton to become more energy efficient using cost-effective measures.

This assessment offers a systematic framework to analyze energy use for existing buildings at MCB Camp Pendleton while balancing other priorities such as installation mission, construction costs, and Base security. The assessment begins with a baseline of current electrical, and natural gas consumption. Energy conservation and efficiency projects are explored to identify economic approaches to minimize energy demand. Renewable energy generation technologies are then examined for their potential to meet the remaining energy goals. This report provides recommendations for energy conservation, energy efficiency, and renewable energy projects. This report is designed to give MCB Camp Pendleton decision makers (such as the Energy Manager or Base facilities personnel) a clear understanding of the opportunities of energy reduction in existing buildings and the steps to implement them.

Problem Statement

The Department of Defense ("DoD") is the largest energy consumer in the U.S. government. In fiscal year (FY) 2008, the DoD consumed 889 trillion site-delivered Btu and spent on the order of $20 billion on energy. (DoD, 2011) The majority of DoD energy consumption is fossil fuel based (coal, oil, natural gas, and electricity). The DoD accounts for about 1.8% of total United States petroleum consumption and 0.4% of the world consumption. (DoD, 2011) A summary of the overall DoD energy use is shown in Appendix F.

In FY 2009, Marine Corps Base Camp Pendleton consumed 983,352 MMBtu of energy and spent approximately $25,000,000 on electricity, natural gas, and fossil fuel. (DoD, 2011) (Gilleskie, 2011) As a result, MCB Camp Pendleton's reliance on a fragile commercial electricity grid and the consumption of non-renewable fuel sources may create a serious risk in the long-term ability of the Marine Corps to carry out their mission. In addition, MCB Camp Pendleton's current energy use demands enormous economic resources. The unnecessary diversion of the Marine Corps funding to its energy needs can put the lives of many active military personnel in deployed environments such as Iraq, Afghanistan, and Saudi Arabia at risk. (USMC, 2011)

Significance of the Problem

MCB Camp Pendleton should take appropriate action towards more efficient energy and water usage and towards developing renewable energy resources. It is an opportunity to turn energy challenges into opportunities. The following are some reasons why energy reduction at MCB Camp Pendleton is important.

1. Energy and water resources are essential elements that sustain and enhance MCB Camp Pendleton's combat readiness. (Gilleskie, 2011)
2. MCB Camp Pendleton primarily relies on off-site power generation and is dependent on commercial grids and other regional infrastructure for power distribution. This dependence leaves MCB Camp Pendleton vulnerable to power disruption and creates a significant risk to the execution of its critical mission. (USMC, 2011)

3. Global demand for energy is forecast to grow 57% over the next 25 years. U.S. demand for energy is expected to increase 31% within 25 years. Electricity demand is expected to grow at least 40% by 2032. (U.S. EIA, 2011)
4. The United States imports over 58% of its oil and depends on unstable countries for supply. Worldwide demand is at 97% of refining capacity. These factors directly link our country's economy to the availability of oil making it vulnerable to any disruption in oil refining and distribution capacity. (U.S. EIA, 2011)
5. 50% of U.S. electrical generation relies on coal, a fossil fuel; 85% of U.S. greenhouse gas emissions result from energy-consuming activities supported by fossil fuels. (USMC, 2011)
6. Competition for water – resulting from population growth, industrial demand, and aquatic ecosystems requirements – demonstrates the need for conservation to ensure a high-quality sustainable water supply.

Report Objectives

The purpose of the report is to identify the most economic and potentially efficient ways to reduce the energy demand for existing buildings at MCB Camp Pendleton. The report's objectives are briefly summarized here and are outlined in detail in the remaining sections of the report. They are listed in order of importance and feasibility.

1. **Assess Current Energy Demand and Usage**

This objective establishes a baseline condition for current energy demand and usage as a metric to measure achievement of conservation goals.

2. **Identify Building Specific Energy Conservations Measures:**

This objective looks at ways to limit the amount of energy required to accomplish operations, training, and life style activities in existing buildings.

3. **Identify Energy Efficiency Projects:**

After identifying energy conservation strategies, this objective identifies specific on-site energy efficiency projects and measures their effect on MCB Camp Pendleton energy consumption.

4. **Identify Renewable Energy Projects:**

After taking conservation and energy efficiency projects into account, this fourth objective identifies on-site renewable energy projects for electricity and heat production.

Project Timeline

While this report will be completed in under a year, the development and implementation of the resulting recommendations will likely take much longer to implement due to the size and nature of the project. The project timeline is also influenced by factors such as permitting, environmental review and contract bidding, which are often lengthy processes. The energy conservation and reduction process is detailed below in Figure 1.

Figure 1 – The Reduction Process and Strategy

Source: NREL 2011

The phased progression from a typical installation to an installation that has a reduced energy load is illustrated in Figure 2.

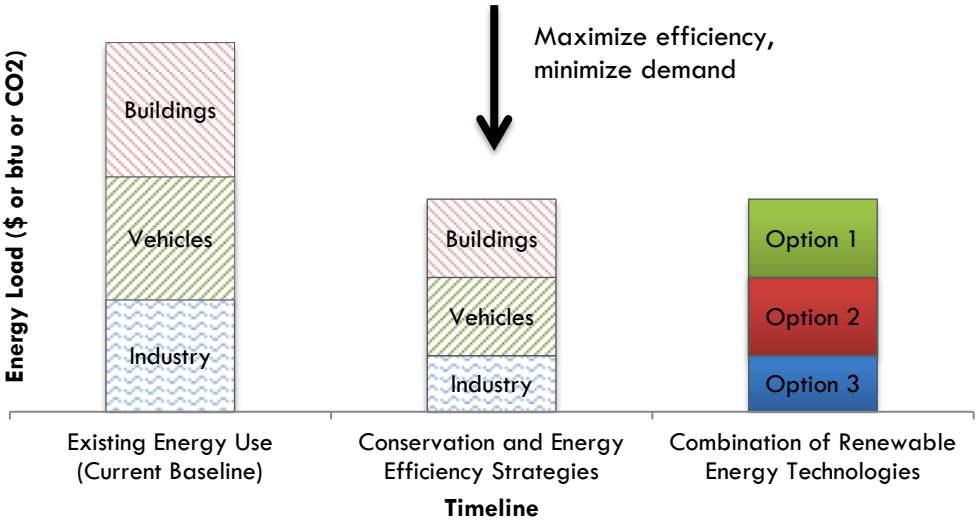


Figure 2 – A Typical Phased Energy Reduction Plan

Scope of the Report

This focus of this report is on the energy used in buildings that are subject to Federal and DoD energy mandates. MCB Camp Pendleton was selected because of its pre-existing strong history of energy conservation and due to its extensive track record of successful energy projects in existing buildings. Buildings and facilities are responsible for the majority of the electrical energy and natural gas consumption at MCB Camp Pendleton. While new buildings have the greatest potential for energy efficiency, building retrofits can also save a substantial amount of energy. According to the NREL, a typical building can be retrofitted to reduce energy consumption by at least 30%.

A. Assessment Area – Area 22 "Camp Chappo"

It is beyond the scope of this report to conduct detailed energy assessments of the approximately 4,300 plus buildings at MCB Camp Pendleton. However, through discussion with Base personnel, analysis of the previous efficiency work, and a visit to several of the facilities on Base, this report evaluates a few buildings within Area 22 "Camp Chappo" as examples of good candidates for a more detailed energy assessment. However, numerous energy efficiency measures, such as lighting enhancements, HVAC replacements, and buildings retrofits can be easily applied to additional buildings and facilities in other areas of the Base.

Table 1 – Assessed Area 22 Building Overview

Total Number of Buildings within Assessment Area	**68 Buildings**
Total Square footage of Buildings within Assessment Area	**2,268,739 square feet**

Table 2 – Area 22 Building Details

Building Type	Number of Buildings	Total Sq. Ft of Building Category	Percent of Total
Unrefrigerated Warehouse	16	778,672	34%
Small Office	32	1,199,676	53%
Bachelor Enlisted Quarters (BEQs)	5	82,587	4%
School	1	31,613	1%
Health	2	48,642	2%
Miscellaneous/Utility	8	62,747	3%
Restaurant	3	53,054	2%
Retail	1	11,747	1%
Total	**68**	**2,268,739**	**100%**

B. Specific Main Base Facilities

Small offices and unrefrigerated warehouses represent the vast majority of the energy use within Area 22: Eighty-Seven percent (87%) of the total electrical use and Eighty (80%) of the total natural gas use. Therefore, this report provides numerous recommendations that have been developed to reduce energy usage in these specific buildings and facilities only. However, these energy conservation measures can be applied across all building types so long as a specific building energy assessment is conducted. Table 4 provides a general summary of all of the assessed buildings within Area 22.

Table 3 – List of Assessed Buildings – Area 22

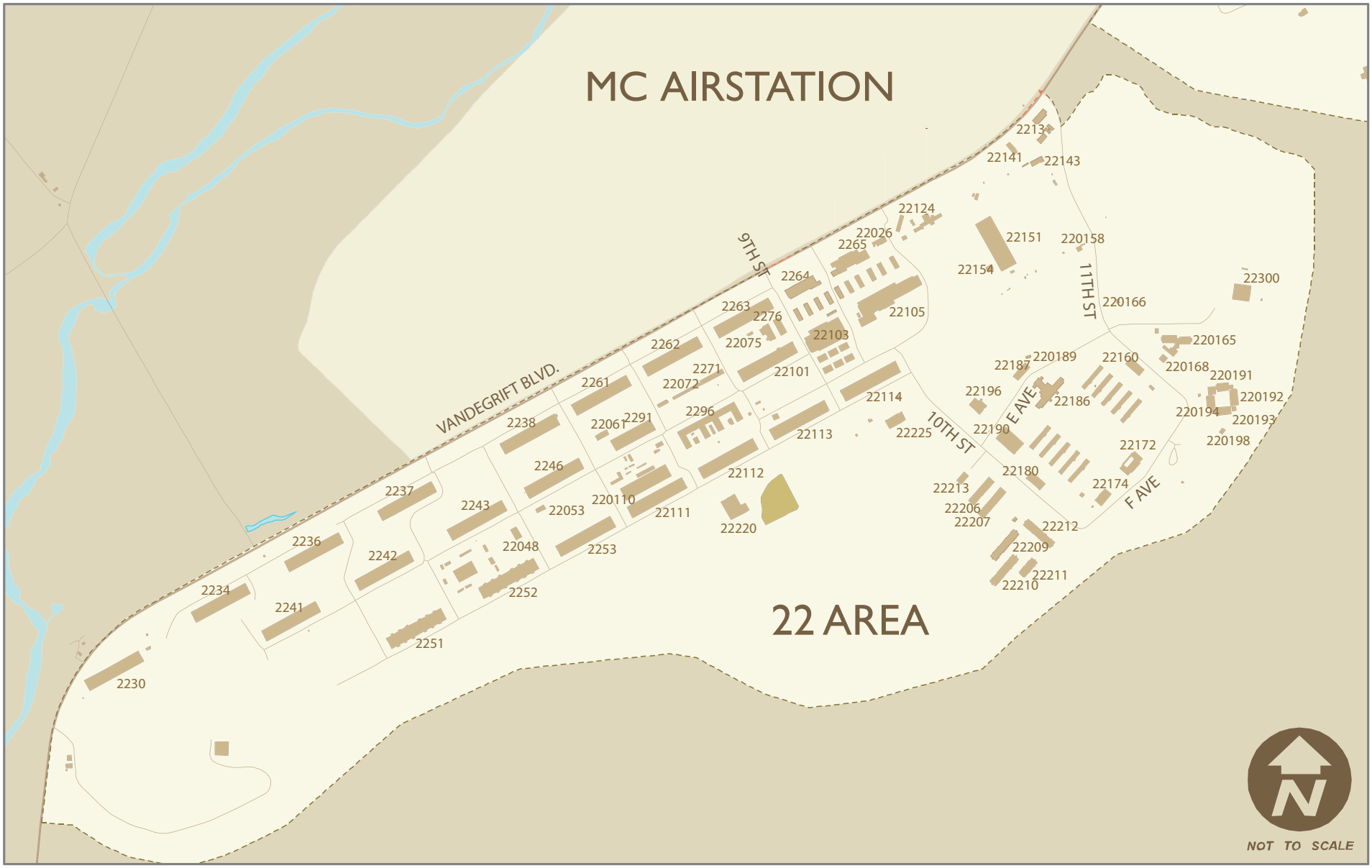
Building Number	Building Type	Total Sq Ft.	Total Annual Usage (kWh)	Total Annual Usage (MBtu)	Year Built
2242	Unrefrigerated Warehouse	64,318	292,003	135.067	1975
2261	Unrefrigerated Warehouse	66,993	304,147	140.685	1955
22101	Small Office	66,913	811,650	140.516	1990
220101A	Small Office	7,682	93,187	16.133	1990
220193	Bachelor Enlisted Quarters	11,739	188,994	724.280	2012

Source: Appendix D

1. **Offices**: There are 32 buildings categorized as small office buildings within Area 22. They comprise an area of 1,199,676ft^2. Small offices comprise 53% of the total Area 22 building square footage. A walk-through inspection of office buildings 22101 and 220101A was conducted to assess energy efficiency improvement potential.

2. **Warehouses**: Unrefrigerated warehouses comprise 34% of the total facility area within Area 22. Area 22 has 16 buildings categorized as unrefrigerated warehouses with a total area of 778,672 ft^2. Many of the warehouses also have small amounts of office space in them. Table 4 provides a summary of the assessed warehouses. A walk-through inspection of warehouse buildings 2242 and 2261 were conducted to assess energy efficiency improvement potential.

Map of Assessment Area



CAMP PENDLETON LEGEND

- Interstate
- State Hwy
- Primary Roads
- Secondary Roads
- Housing Area
- Cantonment Areas
- Building
- 2243

ASSESSMENT MAP CAMP PENDLETON

Renewable Energy Assessment

In addition to the assessment of existing buildings and facilities, a basic screening of the renewable energy opportunities for Area 22 was conducted. The initial screening evaluated the following technologies: photovoltaic (PV), wind, biomass, and micro-turbines. An analysis determined the basic technical and economic feasibility of implementing these technologies at MCB Camp Pendleton (Area 22) and, as a result, several technologies were eliminated from further analysis. Promising and potentially feasible technologies that are evaluated in this report are micro-turbines and photovoltaic power.

Key Project Considerations

The overall goal of this report is to recommend optimal energy reduction strategies that support MCB Camp Pendleton's existing energy policies and mandates. However, attention must be given not only to existing energy policies and practices but also to factors in Marine Corps mission compatibility, Base security, project economics, and site resources. These recommendations should take into consideration the following constraints:

Mission compatibility: The fundamental objective of the Marine Corps is the protection of the security of the American people and National interests. Thus, the top priority for MCB Camp Pendleton is always geared to achieve this goal. Even if attractive by other measures, incompatibility with the MCB Camp Pendleton's core mission eliminates any energy-related proposal that does not serve this goal. For example, wind turbines sited near an airfield is a technology incompatible with the Base's mission to conduct flight operations due to the radar interference caused by wind turbine blades. (Gilleskie, 2011)

Security: Base security, as well as overall physical security of the installation, must be maintained or enhanced by MCB Camp Pendleton's energy system. For example, a biomass-fueled power system may be unsuited for some sites due to the off-site truck traffic required to bring in fuel. On the other hand, the ability to meet MCB Camp Pendleton's critical energy load using on-site renewable sources (e.g. landfill gas, geothermal power, solar energy) in an "islanding mode" may greatly enhance energy

security. (NREL, 2011) This is underscored not only by the threat of malicious activities (e.g. physical or cyber-attacks), but also by the possibility of major blackouts such as have occurred in Southern California many times in recent decades. Moreover, additional blackouts are anticipated due to California's aging electric grid infrastructure, a decreased investment in proper maintenance, increasing demand, and the lack of situational awareness of the part of grid operators. (USMC, 2011) A 2008 Defense Science Board report stated that critical military missions are at a high risk of failure in the event of an electric grid breakdown. (Defense Science Board, 2008)

Economics: Life-cycle, system-based economic assessment of alternatives should reflect such factors as technological maturity, fuel availability and cost, energy storage requirements, distribution and interconnection arrangement, financing options, federal/state/local incentives, environmental impacts, costs for operations, maintenance, repair, and parts replacement. In short, when examining the feasibility of energy efficiency measures, a proper cost-benefit analysis is always necessary.

Site resources: Energy system siting opportunities (buildings; disturbed or undisturbed land; accessibility) varies among installations, as does the local climate, renewable energy resources, and electrical system interconnection opportunities. Due to the large geographic area of the Base, and the number of buildings and facilities it includes, MCB Camp Pendleton offers tremendous potential resources for generating energy, particularly renewable energy. (DoD, 2011)

Key Project Stakeholders

This report is written for those key decision-makers who have a significant interest and influence on MCB Camp Pendleton's energy strategy. Key stakeholders may include; the Base commander, the Base energy manager, facilities and maintenance personnel, the Base environmental manager, the Base public affairs officer, the Base security officer, the Director of the County of San Diego Public Works Department, and San Diego Gas and Electric (SDG&E) personnel. The major stakeholders are listed below.

- **Marine Corps Installations West (MCI West):** is the regional authority on energy policy and establishes overall policy guiding Base energy use.
- **Naval Facilities Engineering Command (NAVFAC):** maintains and operates the base distribution network and MCB Camp Pendleton pays NAVFAC for distribution system maintenance. NAVFAC also manages all energy projects.
- **San Diego Gas & Electric Company (SDG&E):** is a combined gas and electric distribution utility serving more than three million people in San Diego and the southern portions of Orange counties. SDG&E delivers natural gas to over 845,000 customers in San Diego County, including MCB Camp Pendleton.

The Decision-Making Process

MCB Camp Pendleton is a command driven organization and can effect changes more easily than other government organizations. However, there are also impediments to this hierarchy. For example, there has been little research and development of installation energy on military installations. (DoD, 2011)Also, military installations cannot necessarily retain the monetary savings from reducing energy demand. However, in this case, the Marine Corps hierarchy offers many advantages in the implementation of these opportunities in terms of speed and scale. In other words, military installations are often able to implement capital projects with little local public review and controversy.

Background Site Information

MCB Camp Pendleton occupies approximately 125,000 acres within northern San Diego County with San Clemente to the north, Oceanside to the south, Fallbrook to the east, and the Pacific Ocean to the west. The Base contains the largest undeveloped portion of coastline in Southern California. A leased portion of the northwestern area of the Base is leased to Southern California Edison (SCE) for the purpose of operating the San Onofre Nuclear Generating Station. (USMC, 2012) MCB Camp Pendleton supports approximately 42,000 military personnel, 6,100 civilian personnel, and at times, has a population of more than 51,000 Marines and Navy personnel. (DoD, 2011) Table 5 shows a breakdown of the Base population.

Area 22 consists of large warehouse buildings with some administrative and maintenance facilities. The eastern half of the Area 22 includes operations and training, pistol

and rifle ranges, housing and personnel support (including barracks and a mess hall), and recreation facilities. (United States Army Corps of Engineers, 1997)

Table 5 – Base Population

Military Personnel	42,916
Civilian Personnel	6,100
Other (Contractors)	2,491
Total	51,507
Source: DoD Base Structure Report Fiscal Year 2011 Baseline p. 43	

MCB Camp Pendleton is home to: the 1st Marine Expeditionary Force (I MEF); the 1st Force Service Support Group (1st FSSG); the 1st Marine Division (1st MARDIV); Marine Corps Air Station (MCAS) Camp Pendleton; Marine Air Group-39 (MAG-39); Marine Wing Support Squadron-372 (MWSS-372); U.S. Navy Assault Craft Unit-5 (ACU-5); and other Tenant Organizations such as 3rd LADD Battalion, MACS-1, MASS-3, 4th LAI, U.S. Naval Hospital, and the United States Army Reserve Center (USARC). (USMC, 2012)

MCB Camp Pendleton is considered one of the busiest Department of Defense (DoD) installations and is the most complete West Coast military training facility, which includes the Marine Corps' largest amphibious assault training facility. MCB Camp Pendleton controls and supports all of the training areas, ranges, and buildings within its boundaries. The Base's wide variety of training facilities includes beach and mountainous terrain for troop movement training and small arms and artillery firing ranges. (USMC, 2012)

Base Climate and Environment

The climate is mild at MCB Camp Pendleton. Staff indicates that coastal fog routinely stops at the low mountains and mountain passes between the Base and the coast. Therefore, MCB Camp Pendleton experiences slightly higher temperatures than at the coast. According to NOAA, rainfall at Camp Pendleton is heaviest during the winter months particularly late November through early February. Rainfall amounts increase inland at higher elevations.

The Base ecosystem includes beaches, bluffs, mesas, canyons, mountains, and Southern California's only free-flowing river. There are more than 1,000 species of plants, fish and animals, some of which are either threatened or endangered. (United States Army Corps of Engineers, 1997) NEPA and ESA issues are addressed later in the report.

Existing Base Infrastructure

According to Base staff, MCB Camp Pendleton operates and maintains its own utility and energy distribution systems. Below in Table 6 shows the various utility statistics. Table 7 shows the total property at MCB Camp Pendleton, and Table 8 shows the total number of buildings.

Table 6 – Base-wide Facilities Statistics

Acres of Base	127,158	Miles of Sewer Lines	150	Miles of Steam Lines	6
Buildings	2,600	Landfills	2	Miles of Gas Lines	145
Miles of Road	530	Water Wells	33	Miles of Electrical Lines	335
Railroad Tracks	14	Miles of Water Lines	375	Electrical Substations	215
Sewage Treatment Plants	7	Water Reservoirs	25	Boilers	487
Source: MCB Camp Pendleton Facilities Homepage					

Table 7 – Total Real Property

		Owned		Leased		Other	
Site	**Nearest City**	**Count**	**SQFT**	**Count**	**SQFT**	**Count**	**SQFT**
MCB Camp Pendleton	Camp Pendleton	1,719	17,993,823	36	51,744	2,608	11,114,773
Source: DoD Base Structure Report Fiscal Year 2011 Baseline p. 43							

Table 8 – Total Buildings at Camp Pendleton

Total Buildings	4,363
Acres Owned	124,863
Total Acres	127,158
Source: DoD Base Structure Report Fiscal Year 2011 Baseline p. 43	

Energy Baseline

The purpose of the energy baseline contained in this report is to evaluate the energy reduction potential at MCB Camp Pendleton and to serve as a reference point for measuring energy conservation progress. This baseline will provide a summary of certain types of energy specifically used within Area 22 in a full range of mission and support activities. This includes electricity and natural gas provided by San Diego Gas and Electric (SDG&E) and energy generated and consumed on-site. Utility costs for the last seven years have been collected to establish an accurate baseline. Anticipated major changes in the MCB Camp Pendleton's energy use (increases or decreases) are addressed to a lesser extent.

Present Energy Baseline

Energy usage for the Base has been collected along with estimated electricity and natural gas usage for Area 22. Data has been collected for electricity and natural gas consumption in buildings, facilities, and infrastructure within Area 22. This includes electrical energy and natural gas used primarily for heating and lighting. Energy use data at the level of individual buildings has been collected to a limited extent, but some data only exists at an aggregate level. Current electricity and natural gas costs have also been collected. Energy use data by building type was acquired from SDG&E and extrapolated from the 2006 California *Commercial End-Use Survey*. Figure 3 shows the total estimated energy use for the entire installation. Additional MCB Camp Pendleton energy use information is presented in Appendix A.

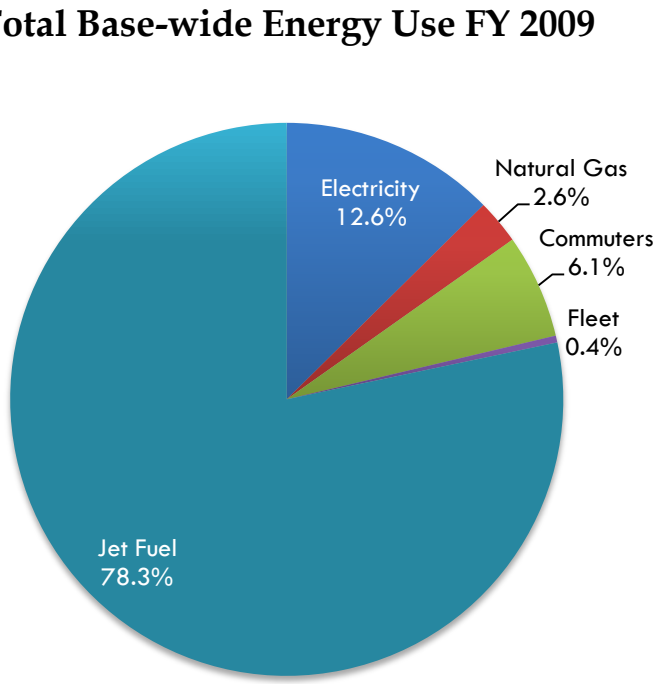


Figure 3 – Total Base-wide Energy Use FY 2009

Base Energy Consumption

The total baseline energy usage for MCB Camp Pendleton in 2009 was 983,352 MMBTU. (DoD, 2011) Table 9 shows total Base energy use in terms of total consumption, on-site energy production, and on-site renewable energy production. Table 9 also provides a comparison of

energy use with nearby Marine Corps installations within California. Additional MCB Camp Pendleton energy use data is available on Appendix A.

Table 9 – Energy Use Comparison – Installation Wide

Installation	State	FY2009 Energy Consumption (MMBTU)	On-Site Energy Production (MMBTU)	On-Site Renewable Energy Production (MMBTU)
MCB Camp Pendleton	CA	983,352	513,250	1,645
MCAS Yuma	CA	192,471	32,209	130
MCAS Miramar	CA	257,344	96,410	123
MCLB San Diego	CA	289,064	217,975	1,075
Source: FY 2010 DoD Annual Energy Management Report Appendix I- Energy Consumption and Intensity by Installation				

Because this report focuses exclusively on buildings and facilities, jet fuel (78.3%) and Base fleet and employee commuter (both civilian and military) personal fuel use (6.1%) are not really contained in this analysis. Also, the amounts of fuel used for tactical fight operations are outside of the control of the Base energy manager and are not part of this analysis. While not directly examined in this report, the potential to reduce the use of jet fuel in flight operations and gasoline use by fleet and commuting vehicles presents an opportunity for future analysis.

Area 22 Energy Consumption

The baseline energy consumption for Area 22 is summarized in Table 10. As explained in more detail in the procedures and methods section, energy consumption data has been extrapolated from the 2006 CEC *Commercial End-Use Survey* and the most recently applicable SDG&E utility rates.

Table 10 – 2011 Baseline Annual Energy Usage Information - Area 22

Total Electricity Usage (kWh)		23,660,617 kWh
Total Natural Gas Usage (MBtu)		16,010.82 MBtu
Total Electrical Cost		$3,661,675.00
Total Natural Gas Cost		$181,882.96
Total Energy Cost – FY 2011		**$3,843,557.96**
Source: Appendix D		

Electrical Baseline

The total electricity consumption in FY 2011 for Area 22 was 23,660,617 kWh and the total cost per kWh was $3,661,675. The total estimated annual electricity consumption by building category is shown in Table 11.

Table 11 – Estimated FY 2011 Electricity Consumption (Area 22)

Building Category	Total Annual Usage (kWh)	Total Cost per kWh	Percentage of Total Energy
Unrefrigerated Warehouse	3,535,171	$576,233	15%
Small Office	14,552,071	$2,371,988	62%
Bachelor Enlisted Quarters	1,329,655	$216,734	6%
School	211,492	$34,473	1%
Health	920,299	$150,009	4%
Miscellaneous/Utility	609,900	$99,414	3%
Restaurant	2,320,062	$183,164	10%
Retail	181,967	$29,661	1%
Total	**23,660,617**	**$3,661,675**	**100%**

The CEC's 2006 *Commercial End-Use Survey* was used to estimate the end use of Area 22 electrical consumption. The values used are for buildings in the San Diego Gas and Electric (SBG&E) service area. The Survey gave values in terms of kWh per square foot per year of electrical energy usage by building type for heating, cooling, ventilation, refrigeration, cooking, interior lighting, exterior lighting, office equipment, and miscellaneous. This data, along with building square footage data for Area 22, was used to estimate an end-use profile.

Figure 4 below shows the estimated end-uses of electricity (by percentage) within Area 22. Additional energy efficiency calculations can be found in Appendix C.

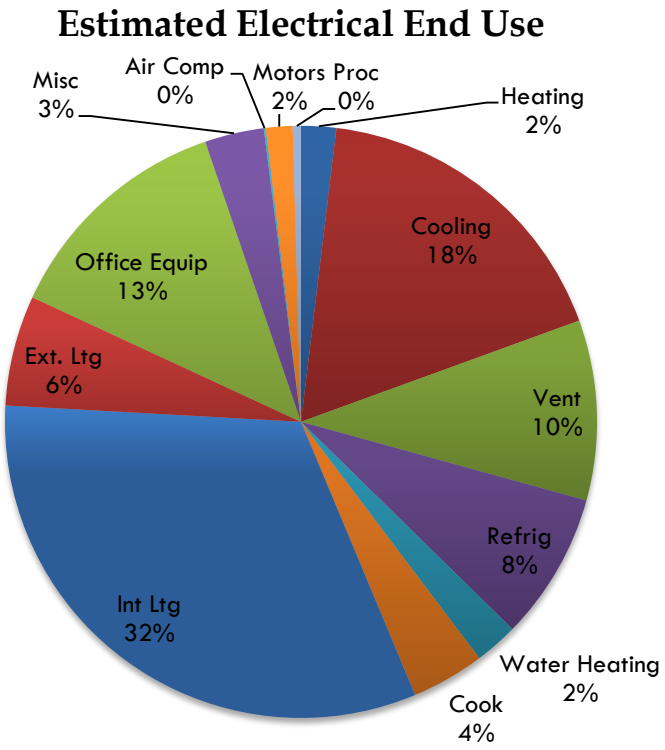


Figure 4 - Estimated End Use of Area 22 Electrical Load

Natural Gas Baseline

The total natural gas consumption in FY 2011 for Area 22 was 16010.82 MBtu, and the total cost per MBtu was $181,882.96. The total estimated annual natural gas consumption by building category is shown in Table 12.

Table 12 –Estimated FY 2011 Natural Gas Consumption (Area 22)

Building Category	Total Annual Usage (MBtu)	Total Cost per MBTU	Percentage of Total Energy
Unrefrigerated Warehouse	1,635.21	$18,576.00	10.2%
Small Office	2,519.32	$28,619.47	15.7%
Bachelor Enlisted Quarters	5,095.63	$57,886.41	31.8%
School	221.29	$2,513.88	1.4%
Health	2,967.14	$33,706.69	18.5%
Miscellaneous/Utility	778.06	$8,838.78	4.9%
Restaurant	2,765.97	$31,421.45	17.3%
Retail	28.19	$320.28	0.2%
Total	**16,010.82**	**$181,882.96**	**100%**

The 2006 CEC's *Commercial End-Use Survey* was also used to estimate the end-use of natural gas consumption for Area 22. The values used are for buildings in the San Diego Gas and Electric (SDG&E) service territory. The survey gave values in terms of kBtu per square foot, per year of natural gas usage, by building type for heating, cooling, hot water, and cooking. Energy use was then converted to MBtu. Figure 5 shows the estimated end uses of natural gas within Area 22. Additional energy consumptions calculations are provided in Appendix B.

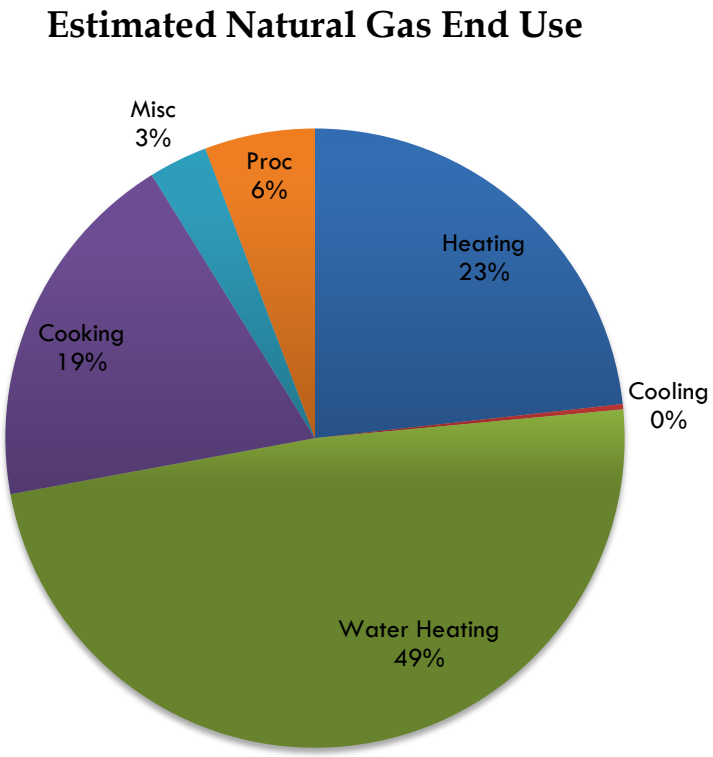


Figure 5 – Estimated End Use of Natural Gas

Area 22 Utility Costs

The current cost of electricity and natural gas is one of the important factors in determining the economic viability of an investment in energy efficiency and renewable energy. During the FY 2011, MCB Camp Pendleton spent $ 3,661,675 in electricity costs and spent $181,882 in natural gas costs for Area 22. MCB Camp Pendleton's electricity and natural gas is provided by SDG&E through NAVFAC. NAVFAC provides utility service and billing for Area 22. The average electrical and natural gas utility rates charged by SDG&E for the last seven fiscal years are shown below in Figure 6 and Figure 7.

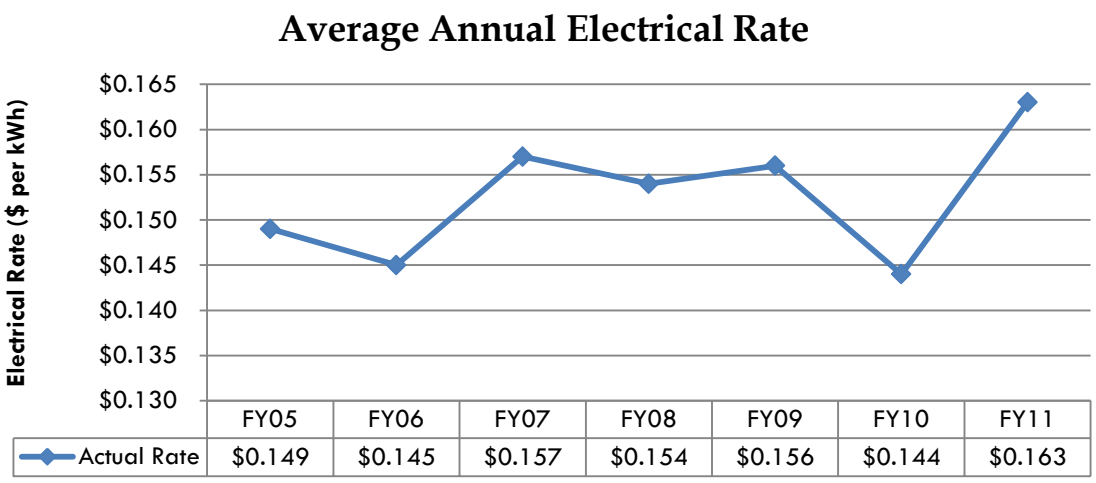


Figure 6 – Average Electricity Prices

According to Base personnel, FY11 payments from the Base to NAVFAC were approximately 0.16 per kWh or $3,661,674 annually. (Gilleskie, 2011)

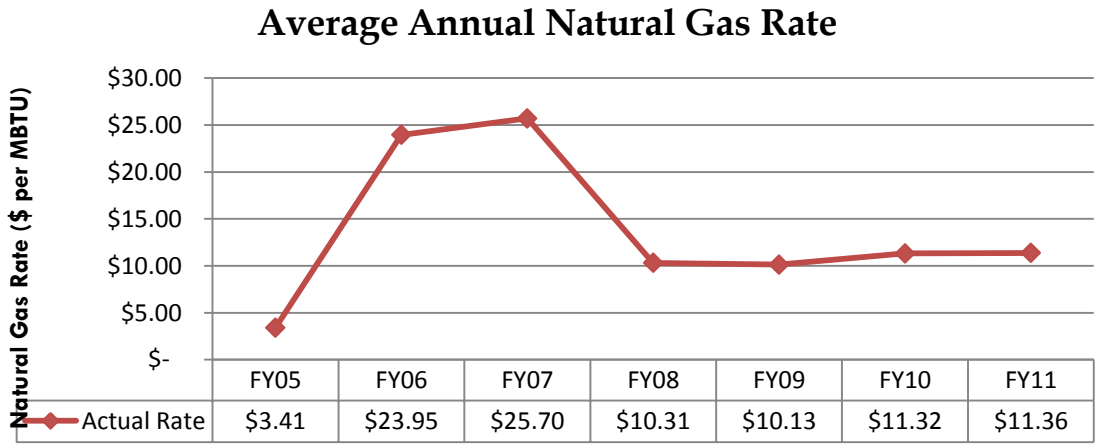


Figure 7 – Average Natural Gas Rates

According to Base personnel, FY11 payments from the Base to NAVFAC were approximately 11.36 per MBTU or $181,882.96 annually. (Gilleskie, 2011) According the Base staff, there is no additional cost built into their natural gas rate from SDG&E. It is unclear why the natural gas rates for the Base vary so dramatically over the last several years, except that a market surplus has resulted in recent cost decreases (Gilleskie, 2011)

Table 13 – Area 22 Estimated Energy Costs for FY 2011

Total Estimated Electricity Cost FY 2011	$3,661,674.98
Total Estimated Natural Gas Cost FY 2011	$181,882.96

Assessed Facilities – Offices, Warehouses, and BEQs

Walkthroughs of various small offices and warehouses within Area 22 were conducted to examine their energy efficiency potential. The load profiles for these office buildings are shown in Figure 8 and Figure 9.

Small Offices: There are 32 buildings categorized as small office buildings within Area 22.[1] They comprise an area of 1,199,676 ft². Small office buildings comprise 53% of the total building square footage for Area 22. An assessment of office buildings 220101A and 22101 was conducted to assess their energy efficiency improvement potential. The load profiles for each small office building are shown in Figure 8 and Figure 9.

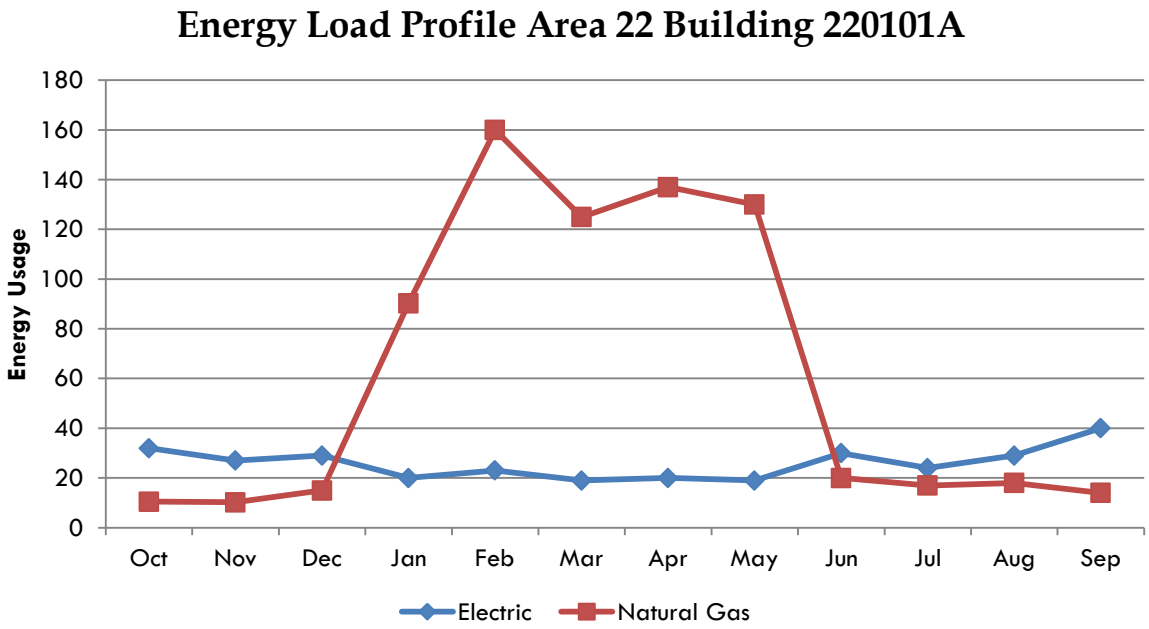


Figure 8 – Energy Load Profile Building 220101A

[1] A Small Office Building is categorized as a commercial building with less than 30,000 sq. ft. Source: CEC

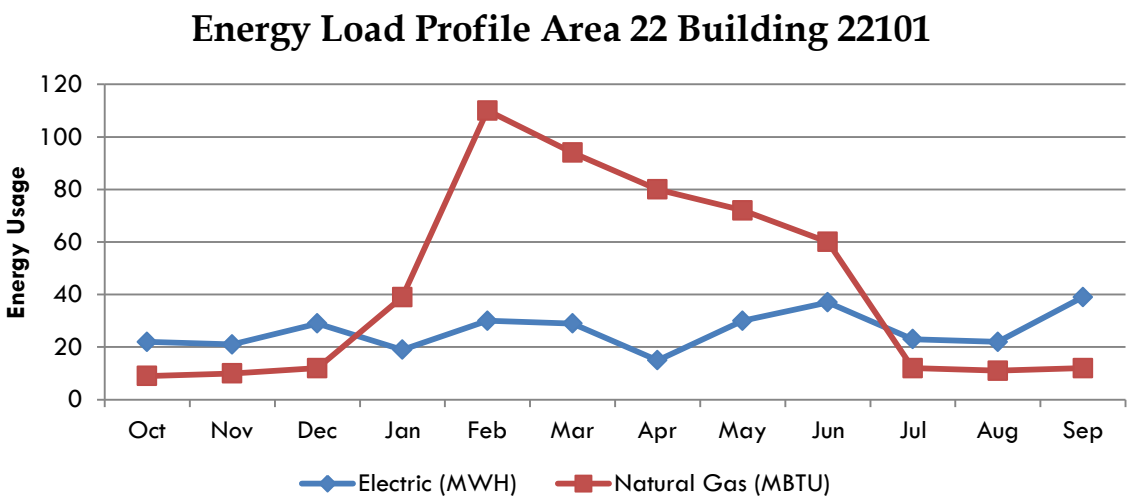


Figure 9 – Energy Load Profile Building 22101

Warehouses: Warehouses comprise 34% of the total building and facility area within Area 22. Area 22 has 16 buildings categorized as unrefrigerated warehouses with a total area of 778,672 ft². Many of the warehouses also have small amounts of office space in them. An assessment of warehouses 2242 and 2261 were conducted to assess energy efficiency improvement potential. The energy load profile for building 2242 is shown in Figure 10.

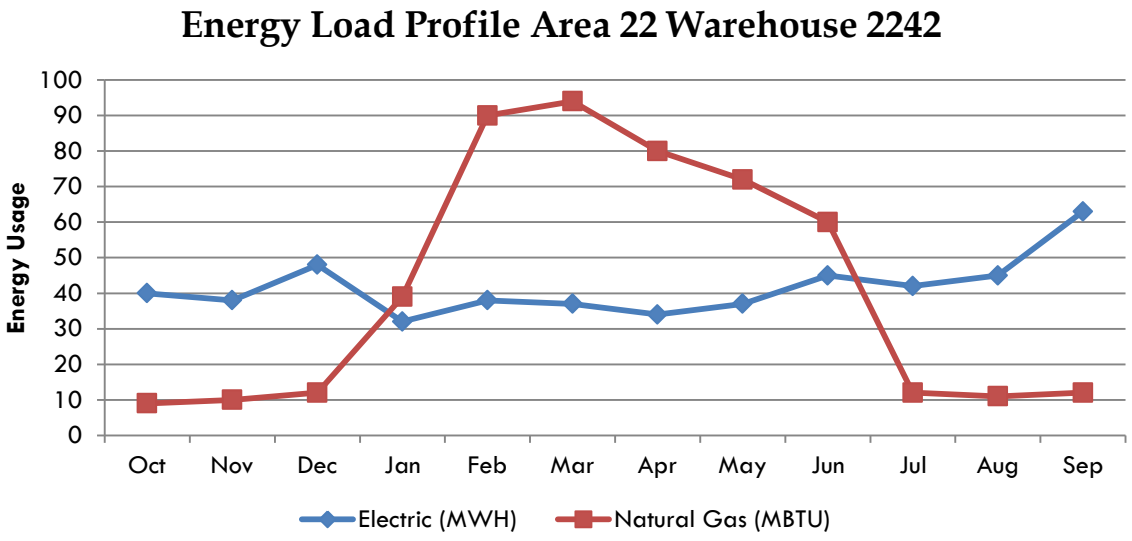


Figure 10 – Energy Load Profile Warehouse Building 2242

Bachelor Enlisted Quarters (BEQs): Area 22 contains a moderate number of housing units for active military personnel. These units are defined as Bachelor Enlisted Quarters (BEQs). According to Base staff, BEQ facilities are not controlled by the Base energy manager and receive their own utility bills. The residents of the housing facilities receive unlimited utilities (i.e. unmetered) with their rent, so they have limited incentive to conserve. BEQs comprise only 4% of the total building and facility area within Area 22 but still have potential for significant energy conservation. Area 22 has 5 buildings categorized as BEQs with a total area of 82,587 ft^2.

Existing Base Energy Reduction Projects and Programs

MCB Camp Pendleton is already a leader in deploying renewable energy technologies as several renewable energy systems have previously been installed on the Base. In 2007, MCB Camp Pendleton saved energy and money and substantially reduced greenhouse gas (GHG) emissions through the use of solar hot water (SHW) and photovoltaic (PV) arrays. The Base also implemented two integrated solar thermal/PV systems at Area 53 and Area 62 training facilities. These projects demonstrate MCB Camp Pendleton's continuing commitment to energy conservation while endeavoring to meet Federal requirements for on-site renewable energy and solar hot water generation. (FEMP, 2009)

In recent years, the energy team at MCB Camp Pendleton has achieved a 44 percent reduction in energy consumption reaching the energy goal mandated by Executive Order 13123 six years earlier than required. The Base realized these accomplishments despite a 2 million-square-foot increase in facility space. The Marine Corps cut the Base's energy use through successful implementation of energy savings performance contracts ("ESPCs") and utility energy services contracts combined with staff energy education and awareness programs. Projects included decommissioning a large central steam plant and incorporating Leadership in Energy and Environmental Design (LEEDTM) standards into all new construction projects. The Base saved more than $3 million in energy costs and almost 280 billion Btu in FY 2004 alone.

Table 14 – PV Project Overview

Project at a Glance	
Pool Capacity	500,000 gallons per swimming pool
System Overview	Integrated solar hot water/photovoltaic arrays
SHW Collector Area	6,384 square feet per swimming pool
PV Panel Area	1,485 square feet per swimming pool
Solar Thermal Output	4,371 MBtu annually (combined)
Solar Electricity Output	63,200 kWh annually (combined)
Utility Partner	San Diego Gas & Electric
Year of Completion	2007
Total Cost	$1.1. million
Annual Energy Cost Savings	$101,600
Utility Incentive	$90,285 (California Solar Initiative EPBB)
Payback	10 years
Source: FEMP – Department of Energy PV Case Study	

Base Community Pool Project

In 2007, the Base implemented two integrated solar thermal/PV systems at its Area 53 and Area 62 training pools. These projects demonstrate the Base's continuing commitment to energy conservation while helping to meet Federal requirements for on-site renewable energy and solar hot water generation. Important details of the project are highlighted in Table 14.

Pool Project Overview

With a capacity of 500,000 gallons each, the training pools provide daily training for Marine Corps personnel year round. The pools originally used natural gas for water heating and electricity for pumps and other mechanical equipment. MCB Camp Pendleton decided to change its practices and take advantage of its abundant solar resources to displace natural gas and electricity consumption. (FEMP, 2009)

While solar hot water and photovoltaic technologies have a long history of use within by Federal agencies, MCB Camp Pendleton took a unique integrated approach. Each pool is equipped with 152 SHW collectors (covering 6,384 square feet) and 108 PV modules (covering 1,485 square feet.) The integrated system is supported by a ground-mounted steel structure. Each solar thermal collector is capable of producing 39,400 Btus of energy each day, resulting in combined annual energy production of 4,371 million Btu (MBtu) for both Area arrays combined. As a result, MCB Camp Pendleton eliminated its annual consumption of 54,726 Therms of natural gas for heating the two pools. (FEMP, 2009)

Each PV array is rated to generate 31,600 kilo-watt-hours (kWh) electricity annually, resulting in a combined offset of 63,200 kWh annually.[2] Combined annual electric and natural gas savings for the two training pools is 5,587 MBtu. The MCB Camp Pendleton solar project also reduces annual GHG emissions, including 725,610 pounds of carbon dioxide and 850 pounds of nitrogen oxide. (FEMP, 2009)

The solar systems were part of "whole-building approach" to conserve energy. Other upgrades made to the training pool equipment include variable frequency drives and state-of-the-art temperature controls. This equipment allows staff to minimize energy consumption and maximize the use of solar resources throughout the day. Temperature controls are tied to a Base-wide energy management system (EMCS) that allows operators to monitor all systems at the training pool from remote locations. The result reduces energy costs and the length of the project's payback period.

Pool Project Financing

Project financing originated through a utility energy service contract (UESC) with SDG&E and through Energy Conservation Investment Program (ECIP) funding. The two integrated solar systems cost $1.1 million to construct but will save the Base an estimated $101,600 in electricity and natural gas costs annually. MCB Camp Pendleton also offset some of the construction costs through a California Solar Initiative Expected Performance Based Buydown (EPBB) incentive of $90,285. Final payback for the pool project is less than 10 years. (FEMP, 2009)

[2] Based on manufacturer data and independent testing by the National Solar Rating and Certification Corporation.

Additional Successful Projects

Solar panel installation at a Las Pulgas artillery shelter nears completion as contracted workers finish setting up 672 modules at MCB Camp Pendleton. *Photo taken by Lance Cpl. Daniel Boothe on 5/15/2010 Source: Defense Imagery*

Conservation Programs

As mentioned, MCB Camp Pendleton already has an outstanding energy conservation program. The Base had an FY 2000 goal of reducing energy use per square foot by 20 percent from its FY 1985 baseline and an FY 2005 reduction goal of 30 percent from FY 1985. During 2002, MCB Camp Pendleton aggressively reduced energy consumption by 6 percent. MCB Camp Pendleton was further tasked to identify and accomplish all energy and water conservation actions that pay back in ten years or less by FY 2005 and to improve the efficiency of all industrial facilities energy use by 20 percent by FY 2005. MCB Camp Pendleton has accomplished the 20 percent reduction and accomplished the additional 10 percent reduction by FY 2005 as required. (USMC, 2002)

The reductions were accomplished in the following manner: **1**. a de-lamping effort disconnected 20,285 lights Base wide and installed 1,745 motion detectors/photo cells for an

annual savings of 2,311,000-kilowatt hours (kWh), **2**. all Base traffic lights were replaced with LED lights for an annual savings of 1,350,000 kWh and **3**. Bachelor Enlisted Quarters (BEQs) had more than 20,000 incandescent lights replaced with compact fluorescent lights resulting in an annual savings of 850,000 kWh, and **4**. Six warehouses were outfitted with solar day-lighting technology, thereby saving 300,000 kWh annually while several hundred electric dryers were replaced with natural gas dryers, and **5**. Sixteen solar powered street lights/flashers were installed in remote hazardous areas saving both energy and lives. (FEMP, 2009)

Finally, an all-hands effort was in place to ensure Base wide energy awareness training. These efforts have yielded more than a 450 percent return on investment through rebates, incentives, energy program development, and financial analysis - saving MCB Camp Pendleton even more. The Base also qualified for more than $200,000 in energy rebates. The Federal Energy Management Program (FEMP), a program of the Department of Energy (DOE), honored the Base in October 2002 for utilizing its Utility Energy Service Contract and for working with SDG&E to finance $5.9 million in energy efficiency projects. (FEMP, 2009)

Renewable Energy Resource Assessment

Additional data on promising renewable energy technologies has also been evaluated for possible application at Base Area 22. In this section, those technologies that appear to be feasible and financeable are evaluated. Table 15 provides a summary of the renewable energy projects potentially feasible at MCB Camp Pendleton. However, the most promising and potentially feasible technologies that are evaluated in this report are micro-turbines, photovoltaic power, and Day-lighting.

Table 15 – Renewable Energy Assessment Overview

		Orange = Limited Compatibility Red = Not Compatible NE = Not Evaluated					Orange = Limited Compatibility Red = Not Compatible NA = Data Not Available				
		Mission Compatibility					**Resource Abundance/Economic Environment**				
Installation	**State**	**Solar**	**Wind**	**Bio**	**Gthm**	**GSHIP**	**Solar**	**Wind**	**Bio**	**Gthm**	**GSHIP**
MCB Camp Pendleton	CA	A	R	A	R	G	R	G	G	R	NA
MCAS Yuma	CA	A	R	A	A	G	G	A	R	G	NA
MCAS Miramar	CA	A	R	A	R	G	A	G	G	R	NA
MCLB San Diego	CA	A	R	A	R	G	A	G	G	R	NA

Source: FY2010 DoD Annual Energy Management Report Appendix H- FY2009 Renewable Energy Potential

Photovoltaic Power Overview

Photovoltaic Power (PV) panels convert sunlight directly into electricity. They have no moving parts and require very little maintenance, make no noise, and emit no pollution. They are highly reliable and last 25 years or longer. They can be installed on racks on the ground, mounted on poles, or mounted on rooftops or carports. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010)

The solar resource map (see Appendix D) for PV shows the entire Area 22 falls in the 5.0-to 5.5-kWh/sq.m/day category, which indicates a high resource capability. The direct normal solar resource is also significant, with the entire Area 22 having resource in the 5.0 to 5.5 kWh/m2/day category. (NREL, 2012)

PV Case Study

Marine Corps Air Base Miramar in San Diego CA has several PV projects in various stages of planning. The total size of the planned PV projects is approximately 2.3 MW, and the annual energy production will be about 3,500 MWh/yr. This represents approximately 5% of Miramar's total annual electrical consumption. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010)

Micro-turbine Projects

Micro-turbines are small combustion turbines that produce between 25 kW and 500 kW of power. Micro-turbines were derived from turbocharger technologies found in large trucks or the turbines in aircraft auxiliary power units (APUs). Most micro-turbines are single-stage, radial flow devices with high rotating speeds of 90,000 to 120,000 revolutions per minute. (DoD, 2011) They are better suited to supply the energy use of individual buildings at MCB Camp Pendleton than co-generation units, which are typically much larger. These systems are most cost effective when the user is able to take advantage of both the thermal and electrical loads produced by the co-generation unit system. Electrical efficiency is typically between 15% and 40%, and thermal use can make the total efficiency as high as 90%. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010, p. 3) A picture of a sample micro-turbine unit is shown in Appendix E.

Micro-turbine Case Study

Currently the Naval Base in Coronado near Marine Corps Station Miramar, uses two 60 kW micro-turbines to produce 120 kWh of electricity. These turbines also displace 700,000 Btu per hour from the natural gas-fired hot water heater. This system saves the Naval Base $78,000 annually.

Wind Power Projects

According to the 2010 DoD Annual Energy Management Report, the wind resource for all of MCB Camp Pendleton is in the Class 1 category, which is very low. Therefore, a wind energy project is not apparently feasible within Area 22 at this time. (DoD, 2011)

Geothermal/Ground Source Heat Pump Projects

Information on direct geothermal resources at MCB Camp Pendleton (including Area 22) was not available for this report. However, the national version of the geothermal resource map indicates moderate geothermal project potential at MCB Camp Pendleton. Southern California has several geothermal projects, but the industry is not fully developed and project costs would likely be higher than average. Geothermal data was acquired from the 2010 DoD Annual Energy Management Report. Geothermal is most efficient in areas with extreme weather, which does not apply to MCB Camp Pendleton.

Day-lighting

A complete day-lighting system consists of apertures (skylights), to admit and distribute solar light and a controller to modulate artificial light in order to achieve energy cost savings. Day-lighting requires no schedule maintenance, although skylights may add to roof maintenance. Day-lighting can be screened by using a site's solar luminance values to determine the optimum amount of skylight area (as a percentage of total roof area). It is important to balance savings from reduced electric light usage against the cost of installing a day-lighting system and the expense of heat loss through the skylights. (Burman, et al., 2011, p. 25)

Planned Projects: Skylights have been installed in the some of the buildings at MCB Camp Pendleton, so a detailed assessment of the office buildings and warehouses would need to be completed. This report does not include day-lighting for housing and focuses primarily on warehouse and office buildings.

Procedures and Methods

This section addresses the steps taken in establishing an energy baseline and conducting an energy assessment for Area 22. The approach developed for this report includes several steps, which are summarized below and referenced in other sections of the report.

Defining the Project Scope

The first step was to identify the scope of the report, and to define certain parameters of the project, including the project objectives, a geographic boundary, energy uses to be addressed, a project timeline, and possible contingencies.

- **Project Objectives**: The project objectives are straightforward and identify a set of energy projects that reduce energy use within a defined area.
- **Geographic Boundaries**: The physical boundary of the report is Area 22 within MCB Camp Pendleton.
- **Energy Use to be addressed**: In general, all energy use is addressed in the overall baseline, but the individual Area 22 energy assessment focused on existing buildings and facilities. Transportation energy (i.e. gasoline) is not addressed in this report. Also a few tenants operate within Area 22. Their energy use is outside of the purview of the Base energy manager and is therefore, not included in the assessment.
- **Project Timeline:** The recommendations include a well-planned project timeline that addresses factors such as project permitting and possible environmental issues.
- **Contingencies:** The report identifies potential opportunities for additional energy research and identifies difficult areas that may require increased resources or emphasis.

Determining the Energy Baseline

The second step in conducting an energy assessment was to establish an energy baseline for the total energy consumption for Area 22. Baseline data collection, key to a credible assessment, presented a significant challenge due to the limitations in publically available data. In some cases where data was not publically available, it became necessary to collect data from third party sources.

Present Baseline: Establishing the energy baseline for Area 22 was primarily an exercise in data collection. The electrical and natural gas baseline for Area 22 was estimated using data received from the base energy manager, SDG&E, the California Energy Commission, and NAVFAC.

Energy use data at the level of individual buildings was not available; however data at an aggregated level was available.

Area 22 Baseline: The California Energy Commission's 2006 *California Commercial End-Use Survey* was used to estimate the end use of Area's 22 electrical and natural gas consumption. The values used are for buildings in San Diego Gas and Electric service territory. The survey gave values in terms of kWh and kbtu per square foot per year of electrical energy usage by building type for heating, cooling, ventilation, refrigeration, cooking, interior lighting, exterior lighting, office equipment, and miscellaneous. This data, along with building square footage data acquired from GIS maps, was used to estimate an end use profile based on the building types. Additional building details can be found on Appendix B and Appendix H.

Energy Costs: Current electricity and natural gas rates have been obtained from SDG&E for the financial assessment portion of the report. Additional energy costs were provided by Base staff and the U.S Energy Information Agency (EIA).

Energy Load Profiles: The energy load profiles were extrapolated from data from the 2006 *California Commercial End-Use Survey* and monthly SDG&E energy rate data.

Energy Efficiency Assessment

After determining the energy baseline, specific energy efficiency projects and their potential effect on Area 22 energy consumption was identified using an on-site assessment of existing buildings. The assessment consisted of a detailed energy audit of five buildings within Area 22 to determine their energy efficiency improvement potential. This screening identifies energy saving projects and provides possible implementation strategies. The energy efficiency screening was a comprehensive as possible and examined energy uses such as lighting, HVAC systems, water use, appliances, and installation infrastructure such as exterior lighting. Information on existing buildings and facilities included: **1**. Area (square feet), **2**. Building-specific energy consumption (e.g. kWh/sq. ft.) **3.** Building type and **4**. Building age. Information regarding previous energy project undertaken by the Marine Corps were also collected.

Because resources were limited, additional buildings only received a more basic assessment whereby additional energy saving projects were identified. Basic assessments provided a rough estimate of energy saving potential and will require an investment grade

audit before any new projects are implemented. A basic energy screening identified measures such as replacing incandescent light bulbs and replacing old or inefficient boilers.

Renewable Energy Assessment

The renewable energy assessment used a variety of screening tools to examine the renewable energy potential within Area 22. These tools served as a filter for the elimination of less compelling projects from further assessment.

Screening software was used to conduct high level renewable energy assessment to determine the feasibility of projects. The software screening tools used are identified below. The results of the assessment were discussed with Base personnel and site-specific criteria were incorporated into the assessment. In addition to screening software, renewable energy resource maps were used to determine the potential feasibility of certain projects. For example, the DoD Annual Energy Management Report indicates poor wind project potential for Area 22. In addition to the assessment, current plans and past studies for renewable energy projects were reviewed. Finally, the availability of funding for renewable energy projects was reviewed.

Photovoltaic and Micro-turbines Projects: After the screening had been completed and it was determined which technologies appear viable for Area 22, a further in-depth assessment of PV and Micro-turbines was conducted to ensure they work technically, but also satisfy MCB Pendleton existing energy goals and DoD mandates. Project capital costs, project energy savings, environmental benefits, and possible installation impacts were considered. The result of this process is a set of recommendations for specific renewable energy projects.

Resources Used: For the PV analysis, the "In My Backyard (INBY)" solar mapping tool was used. IMBY was developed by the NREL and is designed to calculate energy potential for a PV array covering a given area at a selected site. http://www.nrel.gov/eis/imby

- For the Wind Resource analysis, wind resources maps were used. Wind resource maps were developed by the Federal Government and are designed to calculate wind potential for a wind project. http://www.windpoweringamerica.gov/wind_maps.asp
- For the Bio Resource analysis, the "Bio Power Mapping Application" application was used. This tool was developed by the NREL and is designed to calculate biomass potential. http://rpm.nrel.gov/biopower/biopower/launch

Project Recommendations

Numerous recommendations have been developed to reduce energy usage within existing Area 22 buildings and facilities. Base-wide energy conservation measures, which apply across all building categories, are listed first and then Area 22 building-specific recommendations are examined in further detail.

General Recommendations

The following recommendations can be applied across the board at MCB Camp Pendleton to substantially reduce the amount of energy used at the Base:

Reduce Energy Demand by Engaging People

- **Recommended Action**: Institute an energy awareness campaign and encourage management teams to continue to develop new ways of lowering energy use. Implement energy scorecards to assess energy usage by individual, buildings, or organizations and recognize best performers and practices. Also, the Base should consider energy's connection, beyond electricity or fuel consumption, to the use of water and the consumption of food as well as other consumables.
- **Resources:** The Federal Energy Management Program (FEMP) has published several guides on how to implement an energy awareness campaign. The following are some selected resources on how to adopt an awareness program:

  Creating an Energy Awareness Program
  http://www1.eere.energy.gov/femp/pdfs/yhtp_ceap_hndbk.pdf
  Handbook from the Federal Energy Management Program on how to create an energy awareness program and campaign.
  Promoting Behavior Based Energy Efficiency in Military Housing
  http://www1.eere.energy.gov/femp/pdfs/military_handbk.pdf
  Handbook from the Federal Energy Management Program to promote efficiency in military housing.
  Energy Managers Handbook
  http://www.wbdg.org/ccb/DOD/DOD4/dodemhb.pdf

Department of Defense Handbook for energy mangers with tools to help facility and installation energy managers perform their jobs more effectively by answering questions and illustrating best practices.

Change User Behavior

Through consumer education and feedback, Base consumers can be educated to turn off lights and computer equipment at night and on the weekends.

- **Recommended Action**: Set community goals for energy and water use. Use information and education to inform the Base community about the importance of energy conservation. Create incentives within the community to achieve energy reduction goals. A good example is creating a public awareness campaign.

Specific Area 22 Project Recommendations:

Offices and Warehouses represent the vast majority of the energy use within Area 22 as follows: 77% of the total electrical use and 80% of the total natural gas use. The following recommendations have been developed to help reduce energy usage for these types of buildings and facilities. Energy conservation measures that apply across all building categories are listed first and then several specific building categories (where walkthroughs were conducted) are examined in further detail.

HVAC Systems

Chillers: According to Base staff, many of the current facilities within Area 22 are operating only moderately efficient chillers. It is recommended that they install more efficient state-of-the-art chillers.

- **Recommended Action**: It is recommended that additional buildings be analyzed for chiller upgrades, as these are likely to have significant saving potential.

Air Handling Units: The majority of the air-handling units (AHU) in Area 22 are already efficient air volume (VAV) systems. However, upgrading, the remaining older units to VAV systems would save energy by reducing the amount of air that needs to be heated or cooled.

- **Recommended Action:** It is recommended that the AHU across the Base be evaluated and appropriate units be upgraded to VAV models.

Boilers: The efficiency of the boilers within Area 22 can vary. For example, some of the boilers are newer and very efficient while others could be replaced and save a substantial amount of energy. It is recommended that the boilers that have not been replaced be examined for possible replacement. According to the NREL, boilers with efficiencies less than 85% should be replaced.

- **Recommended Action**: Boilers with efficiencies less than 85% should be replaced with high efficiency boilers that can achieve up to 95% efficiency.

Energy Star Refrigerators: Small refrigerators are located in each of the observed office buildings, and it was assumed that other office buildings contained them as well.

- **Recommended Action**: Replacing numerous small refrigerators within office buildings with more efficient ENERGYSTAR® models could provide energy savings.
- **Energy Savings**: Savings would vary by the model being replaced but would be 50 to 200 kWh per year. Assuming 50 refrigerators are replaced and the savings are 100 kWh per year for each, the total energy savings would be approximately 5,000 kWh per year.

Exterior Lighting and Lamping: Exterior lighting is estimated to represent approximately 6% of Area 22's electricity and consumed 1,425,734 kWh of electricity in FY11.

- **Recommended Action**: It is recommended that all of the exterior lights on the buildings within Area 22 be placed on automatic timers or connected to photoelectric sensors to ensure that they do not operate during the daytime hours. Consideration should be given re-lamping any fixture which can accept newer energy efficient CFL bulbs or LED

lamps. This is particularly true if such bulbs and lamps can be purchased in bulk at substantially discounted prices.

Area 22 Office Building Recommendations

Occupancy Sensors: There are only a few working occupancy sensors currently installed within various small Area 22 office buildings. Occupancy sensors can save considerable energy by turning off the lights when spaces are unoccupied. Large cubicle workstation areas, conference rooms, private offices, and restrooms comprise the majority of the lighting use in building 2125. It is likely that many of these areas are intermittently occupied or vacant throughout the course of the day and, as a result, installing occupancy sensors could achieve energy savings. The savings calculations for these lighting control measures are provided in Appendix C.

Source: NREL

Figure 11 – Typical Open-space ceiling-mounted sensor application and coverage

- **Recommended Action**: Install ceiling-mounted infrared occupancy sensors to control lighting in all office buildings to automatically activate and deactivate space-light based on occupancy. This measure will reduce annual energy consumption by a significant amount.
- **Energy Savings**: Estimated Energy Savings of 440,563 kWh/yr.
  Assumptions:

- The calculation assumes an Electric Energy Intensity of 4.45 for an office building.
- 80% of the lighting was assumed to be appropriate for occupancy sensors.
- 10% lighting energy savings from occupancy sensors was assumed.[3]

Lamp Replacement: The majority of lighting in the office buildings within Area 22 is provided by standard 32 W T-8 linear fluorescent lamps. Light level measurements taken by staff within office building 21122 found that most of the spaces in the building were over-lit based on the lighting standards developed by Illumination Engineering Society of North America (IESNA). The savings calculations for these lighting control measures are provided in Appendix C.

- **Recommended Action**: Replace the existing 32 W lamps with 25 W T-8 lamps. While this is a simple measure to implement, the current ballasts should be checked to be certain that they are compatible with 25W lamps and are operating properly. If they are not, new ballast should be considered. This measure can be implemented immediately or completed in phases. This measure will reduce lighting levels in the building by 15% to 25%, bringing Area 22 closer to the IESNA recommended standards.
- **Energy Savings:** Estimated Energy Savings of 305,796 kWh/yr.

Assumptions:

- The calculation assumes an average lighting power density of 1.3 W/ft2 for 39 buildings.
- 30% of the total electric use for the buildings is assumed to go to lighting.

Area 22 Warehouse Building Recommendations

Install Day-lighting: There are retrofitting opportunities in many of the warehouse buildings because the roofs are metal and un-insulated. If Day-lighting were installed in all of the warehouses, the total building area affected would be 778,672 ft$^{2.}$ The lighting load for an unrefrigerated warehouse is estimated to be 3.84 kWh per ft^2. The total lighting energy usage for all of the warehouses is estimated at 1,533,983.84 kWh per year. According to the NREL,

[3] American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 90.1

Day-lighting systems could reduce energy use by 20% to 60%. Additional information is available in Appendix C.

- **Recommended Action**: Recommend expanding day-lighting to warehouses. It is not recommended in existing office buildings as it is not cost-effective. Also, Day-lighting can be incorporated at no additional cost in the design stage of a new building. Recommend all new construction at Area 22 incorporate day-lighting strategies.
- **Energy Savings:** Assuming a 40% reduction the energy savings would be 613,593 kWh

Possible Additional Improvements: All warehouses use T-8 lighting with automatic controls. The warehouses are largely unconditioned. Several of the warehouses appear to have oversized and outdated boilers. These boilers could possibly be scheduled for replacement with more efficient models under an federal ARRA-funded boiler replacement project.

Area 22 Bachelor Enlisted Quarters (BEQs)

Recommended Actions

1. Install a programmable thermostat in each separate unit in order to save heating and cooling energy. The installation of programmable thermostats is projected to save 351 kWh and 3 MBtu of natural gas per unit. Assuming that 75% of units do not have programmable thermostats, the savings would be 138,645 kWh and 1,185 MBtu. An energy calculation table is provided in Appendix C.

2. Turn off water heaters in unoccupied housing units to reduce natural gas to maintain tank temperature. Turning off water heaters in unoccupied housing units would save 0.4% of the total natural gas consumption assuming that 5% of the units are unoccupied at any given time.

3. Install new bath and kitchen fixtures to reduce the fixture flow rate and water consumption. Sink flow rates could be reduced in the kitchen and bathrooms from the

current 2.2 gallons of water per minute (GPM). A water savings calculation table is provided in Appendix C.

- **Energy Savings**: Estimated Energy Savings of 253 MBtu/yr.

Assumptions: The following information was acquired from NREL and Base personnel and was used for the water/energy savings calculations.

- Standard faucet has a flow rate of 2.2 GPM
- Low flow faucet has a flow rate of 1.8 GPM
- Standard shower has a flow rate of 2.5 GPM
- Low flow shower has a flow rate of 2.0 GPM
- Average person uses 20 gal/day of hot water using standard fixtures
- Average person uses 16.1 gal/day of hot water using low-flow fixtures
- Annual energy saving per person = 0.623 MBtu/yr
- Number of people = 406

Additional Energy Saving Strategies for BEQs: The Area 22 housing areas contain large grass areas with sprinklers. These areas could be replaced with less water intensive landscaping. Also water use could be reduced by optimizing sprinkler water use and placement. The sprinkler system should be linked to an automatic rain sensor which adjusts irrigation to the weather patterns and only waters the grass when absolutely necessary.

Area 22 Medical and Community Buildings

Replace Air Conditioning Unit in the Gym: The Area 22 Gym (Building 22160) is currently air conditioned using a direct expansion (DX) refrigeration cycle unit to cool the building. The total energy usage for cooling for building 22160 is estimated at 68,509 kWh per year.

- **Recommended Action:** Replace the standard DX rooftop AC unit with a hybrid indirect evaporative cooling unit. Tests performed by NREL demonstrate the potential for a 75% savings in cooling energy when using this type of evaporative unit instead of a standard

DX AC cooler. In addition, climate data show that Area 22 is a suitable location for hybrid evaporative cooling, especially in its small buildings.

- **Energy Savings:** Assuming a 75% reduction the energy savings would be 51,382 kWh

Possible Additional Improvements: Area 22 has many office buildings and warehouses for which the above-listed recommendation would be appropriate. Several evaporative cooling units could be combined to serve larger buildings. These units work best in small to medium-sized building. Cooling is estimated to account for 18% of the electrical use in conditioned buildings within Area 22, and as result, a savings of 75% of this energy use could be significant.

Install Day-lighting at the Dental Clinic: There is also day-lighting potential at the Area 22 Dental Clinic. The total lighting energy usage for the Dental Clinic is estimated at 159,255 kWh per year. According to the NREL, Day-lighting systems could reduce energy use by 20% to 60%.

- **Recommended Action**: Retrofit Building 21211 to include Day-lighting
- **Energy Savings**: Assuming a 40% reduction the energy savings would be 63,702 kWh

Specific Area 22 Retail Stores and Gas Station

The McDonalds Restaurant and nearby commercial gas station are on-site commercial facilities under a ground lease that provide goods and services to military personnel and their families. These facilities are not controlled by the Base energy manager and receive separate utility bills. Because these facilities are outside the control of the Base energy manager, they have not been assessed for energy efficiency improvement potential.

- **Recommended Action**: Recommend these facilities be analyzed for energy efficiency improvement potential upgrades required of the tenant when these leases are up for re-negotiation.

Area 22 Miscellaneous Facilities and Utilities

Area 22 facilities in the "Miscellaneous/Utilities" category comprise only a small fraction of Area 22. There are 8 facilities listed in this category. These facilities total 62,747 ft^2 and 2% of the total assessment area.

- **Recommended Action**: Recommend these facilities be analyzed for energy efficiency improvement potential.

Area 22 Project Recommendations for Renewable Energy

Micro-turbines

It is beyond the scope of this report to conduct a detailed assessment of the potential for micro-turbines within Area 22. However, buildings with natural gas usage above 1,500 MBts annually, are sometimes good candidates for micro-turbines. Micro-turbines can be coupled with existing building energy systems and should be sized so that the heat output of the turbine is less than building's overall energy usage. It is possible that other buildings at MCB Camp Pendleton could also be good candidates for micro-turbines; it is also possible these particular buildings would be better suited for solar hot water systems. Regardless of the specific building chosen, micro-turbines are a cost-effective and now reliable technology that could lower the energy baseline at MCB Camp Pendleton. Table 16 provides a summary of potential candidates for a micro-turbine project.

Table 16 – Potential Candidates for a Micro-turbine Project

Building Number	Building Type	Total Sq Ft.	Total Annual Usage (MBtu)
2253	Unrefrigerated Warehouse	65,866	138.318
2261	Unrefrigerated Warehouse	66,993	140.685
2262	Unrefrigerated Warehouse	65,700	137.970
22113	Unrefrigerated Warehouse	66,856	140.398

Cost Analysis: The economics of a micro-turbine system are particularly attractive due to the current energy prices especially natural gas prices. However, SDG&E natural gas rates have fluctuated between $10 and $25 per MBtu over the last few years, while the electric rates have

varied considerably less. In order to justify the large up-front capital cost for a micro-turbine installation, the cost of a Btu of natural gas energy needs to be approximately 40% less than the cost of a Btu of electrical energy. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010) With an electricity price of $0.16 per kWh, natural gas would need to cost less than about $17.50 per MBtu to make micro-turbines attractive at MCB Camp Pendleton. At a natural gas price of $17 per MBtu, the system payback time is about 28 years for an electrical energy price of $0.16 per kWh. However, at the current price of about $10 per MBtu, the payback is about six years. Additionally, when replacing old boilers, Base energy staff should compare the capital cost of a new boiler with a micro-turbine system, since this scenario would likely provide even more favorable economic conditions to support the installation of a micro-turbine. (Gilleskie, 2011)

- **Recommended Action**: Base energy personnel should further examine the possible installation of micro-turbines across the Base in buildings that do not have either a central water heating system or a solar hot water heating system. Solar hot water systems would be preferable to micro-turbines because they do not require fossil fuel energy. However, not all buildings are appropriate for solar hot water systems. Micro-turbines would strengthen the micro-grid within Area 22 due to their ability to provide backup power in the event of a power outage.
- **Recommended Action**: Base energy staff should closely monitor natural gas prices to ensure that micro-turbines remain a cost effective energy generation option.

Photovoltaic Power

A site visit to Area 22 and a discussion with the energy team revealed a number of potential sites for photovoltaic (PV) installation. However, some of the areas were not available for PV installation due to environmental protection issues and concerns. The data shows that it would be possible to place two PV systems on the rooftops of buildings 22101 and 2263 and provide a small amount of renewable energy to Area 22. Data for this simulation was acquired using the In My Backyard (IMBY) software tool provided by the NREL. Table 17 and Table 18 provides some basic design and cost projections for the two PV systems.

Table 17 – PV Simulation Results

	Building 22101	Building 2263
Size (kW):	50.02	25.04
System Type:	Commercial	Commercial
De-rating:	0.77	0.77
Tilt angle (o):	33	33
Azimuth angle (o):	180	180
Data year:	2005	2005
Electric Rate ($/kWh):	0.16	0.16
Source: IMBY PV Simulation Tool		

Table 18 – PV System Profile

	Building 22101	Building 2263
Initial Cost ($/Wdc):	4.59	4.59
Initial Cost ($):	$229,591	$114,933
Rebates ($):	0	0
Tax Credits ($):	$68,877.54	0
After Incentives ($):	$160,700	$114,900
Payback (years):	14.22	18.87
Source: IMBY PV Simulation Tool - NREL		

The amount of electricity generated by these two systems would be 107,533 kWh per year and the total combined cost is estimated at $17,205.28. This costs includes state and federal tax credits and after incentives. Table 19 provides a brief summary while additional simulation data is summarized in Appendix E.

Table 19 – PV System Summary

Total Annual System Output (kWh)	107,533 kWh
Total Combined System Cost ($)	$275,600

Cost Analysis: The estimated cost for installing this amount of PV after incentives and tax credits are applied is $275,600. In addition, currently the capital costs for PV panels are dropping substantially due to market competition. (California Solar Initiative, 2012)

Project Timeline: The simple payback for the PV project scenario would be 14.22 years for the 50 kW system and 18.87 years for the 25 kW system.

Figure 12 – Map of Proposed PV Projects for Area 22

Image courtesy of www.bing.com/maps. - 2012

- **Recommended Action**: Base energy personnel should further examine the possible installation of PV on the rooftops of buildings 2263 and 22101. Regardless of the specific building chosen, PV systems are a cost-effective and reliable technology that could lower the energy baseline at MCB Camp Pendleton.

Project Implementation and Financing Options

The energy team at MCB Camp Pendleton has a variety of available options for the implementation of additional energy efficiency and renewable energy projects. Descriptions of these different options are presented below as follows:

Energy Savings Performance Contracts (ESPCs). ESPCs allow Federal agencies to accomplish energy savings projects without up-front capital costs and without special Congressional appropriations. An ESPC is a partnership between a Federal agency and an energy service company (ESCO). The ESCO conducts a comprehensive energy audit for the Federal facility and identifies improvements to save energy. In consultation with the Federal agency, the ESCO designs and constructs a project that meets the agency's need and arranges the necessary financing. The ESCO guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings accrue to the federal agency. Contract terms up to 25 years are allowed. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010) The average contract price for a Super ESPC contract undertaken by a Federal agency between 1998 and 2008 was $15.3 million. (Federal Energy Management Program) Typically ESPC contracts need to be at least $1 million to $2 million in size to generate interest from the private energy sector. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010, p. 99)

Utility Energy Services Contract (UESC). Another way for Federal agencies to implement efficiency and renewable energy projects is through partnerships with local public utilities. Federal agencies often enter into UESCs to implement energy improvements at their facilities. With a UESC, the utility company typically arranges financing to cover the up-front capital costs of the project. Then the utility company is repaid (with interest) over the contact term from the cost savings generated by the energy efficiency measures. With this arrangement, agencies can implement energy improvements with no initial capital investment; the net "up-front" cost to the federal agency is minimal, and the agency saves time and resources by using the one-stop shopping provided by the utility. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010, p. 99)

Power Purchase Agreements (PPA). A PPA also allows federal agencies to finance on-site renewable energy projects with no up-front capital costs incurred through a PPA with private investors. With a PPA, a developer installs a renewable energy system on agency property under an agreement that the agency will always purchase the power generated by the system. The agency pays for the system through these power payments amortized over the life of the contract. After installation, the developer owns, operates, and maintains the system for the life of the contract. Agency ownership after the term of the contract can also be negotiated. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010, p. 99)

Appropriations, ECIP, ARRA. Energy projects can also be funded directly through agency or government budget mechanisms. Funding through these mechanisms has the advantage of reduced project financing costs. However, government funded projects are not eligible for the benefits of renewable energy generation tax credits sold to private parties. This is often feasible for smaller less cost-intensive projects, such as a re-lamping project. (Booth, et al., Targeting Net Zero Energy at MCAS Miramar, 2010, p. 100)

Incentives. Renewable energy projects at MCB Camp Pendleton would likely be eligible for a variety of state and federal incentives and rebates. Energy projects at MCB Camp Pendleton could also be eligible for tax credits if they were owned or leased by a third party with income tax liability.

1. Federal investment tax credits or rebates for PV, CSP, and solar hot water systems – 30% credit of the capital cost.
2. California Solar Initiative production incentive for PV and CSP systems above 50 kW – payment per kWh produced from systems, $0.22 per kWh for systems owned by private sector, and $0.32 for systems owned by the government. (California Solar Initiative, 2012)
3. California Solar Initiative solar hot water heating SDG&E pilot program is $15 per ft2, up to $75,000 total. (Center for Sustainable Energy California, 2012)
4. Modified Accelerated Depreciation Schedule – A program to reduce tax liability through faster than normal depreciation of the tax basis of the asset. An approximate schedule is shown in Table 20 and was provided by NREL.

Table 20 – Typical Depreciation Schedule

Year	1	2	3	4	5	6
Fraction	0.200	0.320	0.192	0.115	0.115	0.058

Additional Project Considerations

NEPA. When planning for and installing the proposed energy projects, MCB Camp Pendleton must be aware of any possible NEPA environmental considerations. NEPA requires Federal agencies to consider the environmental impacts of projects, including the preparation and use of an environmental impact statement ("EIS") under certain circumstances. The requirements for NEPA review vary based on the specific project undertaken and the nature of the potential environmental concern. There are three possible levels of required analysis: categorical exclusion, environmental assessment, and an environmental impact statement. (U.S. EPA) Building energy efficiency upgrades, rooftop energy systems such as PV, day-lighting, and solar hot water would typically qualify for a categorical exclusion since they are usually modifications to existing facilities and due to the related positive environmental impacts. However, projects such as ground-mount PV or CSP could require more detailed NEPA assessments because they are disturbing land as well as creating potentially negative impacts on the Base flora and fauna. The NEPA environmental assessment would be required to determine if these projects would have a significant adverse environmental impact. If it is determined that the project would have a potentially significant adverse environmental impact, a more detailed environmental impact study would be required. (U.S. EPA)

Additional Overall Strategies and Recommendations

Purchase Renewable Energy Certificates (RECs).

Purchasing offsets or credits could allow MCB Camp Pendleton to achieve a 100% renewably powered status. Since the Base in unlikely to be able to achieve a 100% reduction through energy projects alone, REC purchases are another alternative. For example, tactical jet fuel is essential to the mission of the Marine Corps at MCB Camp Pendleton and cannot be eliminated. The purchase of RECs or carbon credits could offset tactical fuel use and help MCB Camp Pendleton reduce its overall environmental impact.

Biomass Based Jet Fuel

The potential use of jet fuel manufactured from biomass sources presents a large future opportunity for MCB Camp Pendleton. There are currently several military and commercial demonstration projects of biologically-based aviation fuels. However, there is currently no commercially-available and affordable option to replace tactical JP-5 derived from petroleum with a fuel derived from biomass products. (DoD, 2011)

- **Recommended Action**: Monitor the technical development of the demonstration projects at other installations and look for opportunities to reduce the Base's fuel energy footprint with a biomass based jet fuel as soon as possible.

Conclusions and Summary

If MCB Camp Pendleton implements these recommendations, it could possibly reduce its non-renewable electrical use by a significant amount. However, when implementing these recommendations, careful consideration must be given to MCB Camp Pendleton's fundamental defense mission as well as its energy goals, environmental concerns, economics, and overall technical feasibility.

New Energy Baseline: The recommended energy efficiency projects would save approximately 2,026,114 kWh of purchased electrical energy each year. Table 21 shows the breakdown of the electrical savings if the energy efficiency measures are adopted. The recommended energy efficiency measures would save approximately 1,438 MBtu of purchased natural gas each year.

Table 21 – Energy Savings Summary

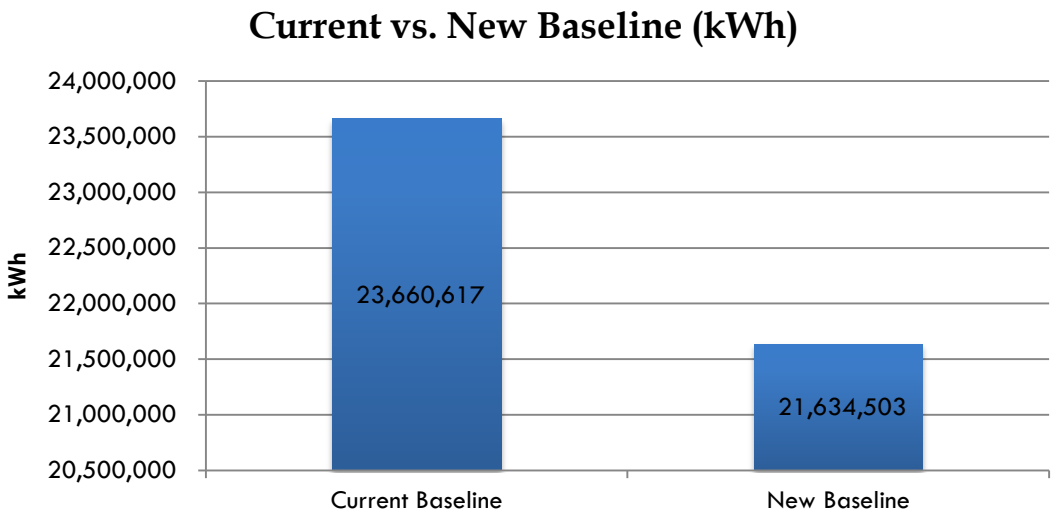
Energy Efficiency Measures	Electricity Savings		Natural Gas Savings		% of Total Savings
Occupancy Sensor	kWh	378,137	MBtu	-	19%
Lamp Replacement	kWh	775,655	MBtu	-	38%
Install Day-lighting	kWh	613,593	MBtu	-	30%
Programmable Thermostat	kWh	138,645	MBtu	1185	7%
Low Flow Fixtures	kWh	-	MBtu	253	
Air Conditioning (Gym)	kWh	51,382	MBtu	-	3%
Install Day-lighting (Dental Clinic)	kWh	63,702	MBtu	-	3%
Area 22 Wide Energy Efficiency Measures					
Energy Star Refrigerators	kWh	5,000	MBtu	-	
	Total	2,026,114	**Total**	**1,438**	**100%**

Cost Savings: These energy efficiency measures would save approximately $346,592 in electricity costs each year and $16,336 in natural gas costs each year. Cost savings are based on a $0.163 per kWh/yr. electrical rate and an $11.36 per MBtu/yr. natural gas rate. This represents a overall savings of approximately 10% of Area 22 energy costs. Table 22 shows the breakdown of the electrical uses if the above recommendations are implemented.

Table 22 – Energy Cost Savings Summary

Electricity Cost Savings	$330,256
Natural Gas	$16,336
Total Cost Savings From Energy Efficiency Projects	$346,592

Figure 13 – Total Electricity Usage Comparison



This project demonstrates that MCB Camp Pendleton is now, in the 21st Century, beginning to transition from its World War II origins and its mid-20 Century energy mind-set to a modern attitude of renovating its facilities and re-examining its energy use profile. Yet, this report also shows that MCB Camp Pendleton has further potential to make additional significant progress towards becoming a more energy efficient installation. If the recommended energy measures and projects are implemented, the Base will achieve a substantial further reduction in electricity and natural gas use. The potential cost savings alone should be a tremendous incentive.

In conclusion, MCB Camp Pendleton has made significant progress through energy initiatives over the last several years. MCB Camp Pendleton has the future potential to expand on these efforts and maintain its leadership in military energy projects by implementing some or all additional energy conservation recommendations.

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Appendix A: Additional Base Energy Information

Figure 14 – Energy Intensities

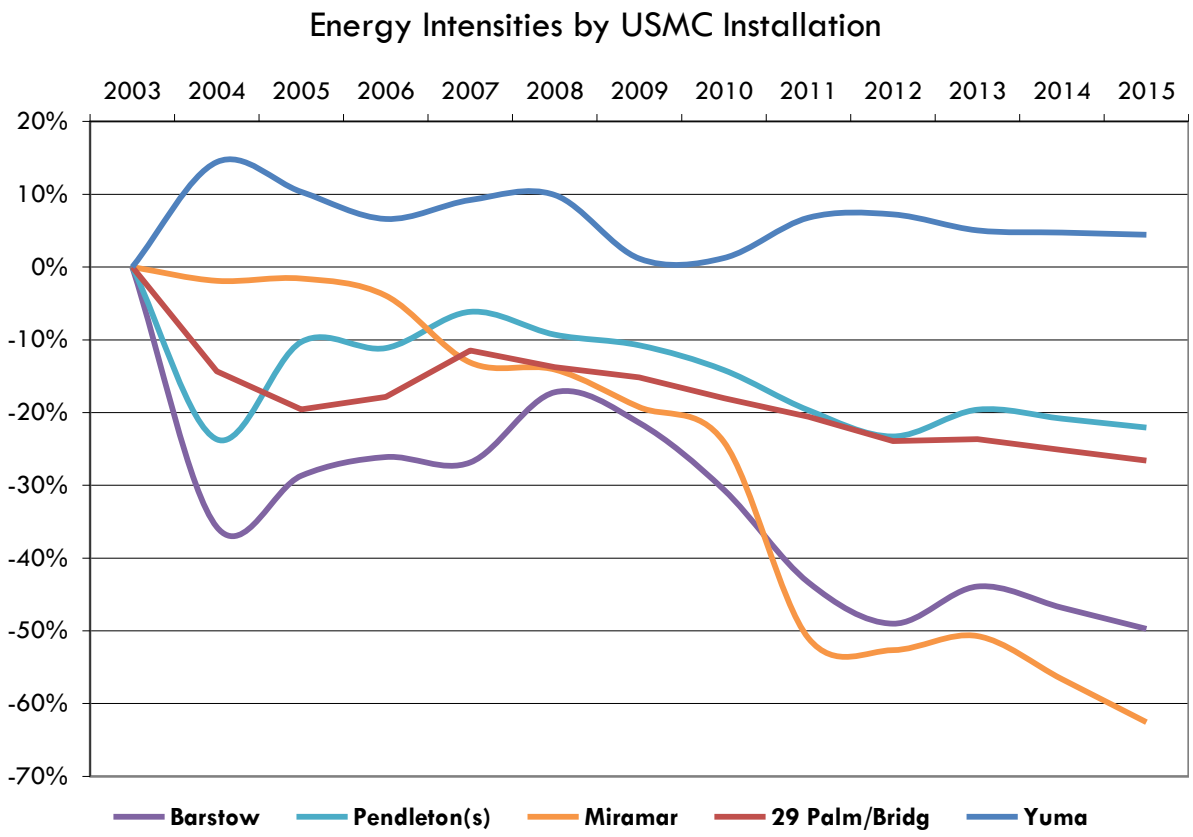


Figure 15 – Base Energy Reduction Progress

Fiscal Year	MBTU	KSF	Cost	MBTU/KSF	% Progress from Previous Year	% Progress from Baseline	Projected increase in KSF
FY2012	863,059	17,000	$13,981,461	50.77	-4.51%	-23.29%	
FY2011	903,795	17,000	$14,413,878	53.16	-6.42%	-19.67%	
FY2010	944,530	16,625	$14,859,669	56.81	-3.80%	-14.15%	
FY2009	981,844	16,625	$15,319,247	59.06	-1.62%	-10.76%	
FY2008	934,157	15,562	$17,566,043	60.03	-3.35%	-9.29%	
FY2007	962,083	15,490	$18,995,625	62.11	5.60%	-6.15%	
FY2006	901,793	15,333	$15,407,161	58.81	-0.94%	-11.13%	
FY2005	910,335	15,333	$15,462,267	59.37	17.55%	10.29%	
FY2004	777,441	15,393	$16,555,088	50.51	23.68%	-23.68%	
FY2003	916,971	13,856	$17,810,987	66.18			

Source: Robert Gilleskie – MCI West

Appendix B: Building Consumption Estimates

Table 23 – Natural Gas Consumption Estimates

Natural Gas Estimates		Values below are in kBtu per ft2 per year					
Building Category	**Total Sq. Ft of Building Category**	**Heating**	**Cooling**	**Water Heating**	**Cooking**	**Misc**	**Proc**
Unrefrigerated Warehouse	778,672	1.7	0	0.2	0	0.1	0
Small Office	1,237,535	0.7	0	0.9	0	0	0.4
Bachelor Enlisted Quarters	82,587	4.8	0	45.8	7.5	3.2	0.4
School	31,613	4.5	0	2.1	0.5	0	0
Health	48,642	14.1	0.9	39.1	4.7	1.3	1
Miscellaneous/Utility	62,747	3.3	0	1.9	0.6	1.3	5.3
Restaurant	15,195	3	0	35.4	138.4	0	0
Retail	11,747	0.8	0	0.6	0.9	0	0.2
Total	**2,268,739**	**34,119,960**	**3,385,123**	**11,768,324**	**3,262,536**	**734,459**	**8,213,057**

Table 24 – Electric Consumption Estimates

EEI Estimates		Values below are in kWh per ft2												
Building Category	**Total Sq. Ft of Building Category**	**Heating**	**Cooling**	**Vent**	**Refrig**	**Water Heating**	**Cook**	**Int Ltg**	**Ext. Ltg**	**Office Equip**	**Misc**	**Air Comp**	**Motors**	**Proc**
Unrefrigerated Warehouse	778,672	0.02	0.65	0.45	0.34	0.09	0.12	1.97	0.24	0.3	0.16	0.03	0.13	0.03
Small Office	1,199,676	0.3	2.26	1.07	0.76	0.37	0.18	3.94	0.8	2.23	0.18	0	0.01	0.04
Bachelor Enlisted Quarters	82,587	0.41	3.35	2.92	1.03	0	0.91	5.17	0.58	0.11	1.07	0	0.53	0.03
School	31,613	0.22	0.99	0.85	0.41	0.1	0.08	2.66	0.69	0.5	0.12	0	0.04	0.03
Health	48,642	0.45	4.21	2.89	0.61	0.11	0.22	4.92	0.46	0.8	3.09	0.01	1	0.15
Miscellaneous/ Utility	62,747	0.09	0.79	0.67	0.6	0.13	0.12	2.65	1.11	0.37	0.72	0.03	2.11	0.34
Restaurant	53,054	0.15	6.43	4.22	10.36	0.52	10.08	6.78	1.94	0.75	2.43	0	0.05	0.02
Retail	11,747	0.09	2.42	1.62	1.42	0.26	0.26	6.72	1.23	0.58	0.55	0	0.22	0.14
Total (kWh)		**452,843**	**4,149,286**	**2,327,615**	**1,908,169**	**561,272**	**943,135**	**7,616,019**	**1,425,734**	**3,042,504**	**763,554**	**25,729**	**344,535**	**106,109.12**

Appendix C: Energy Efficiency Calculations

Table 25 – Installing Occupancy Sensors

Total Assumed Interior Lighting Energy Usage (kWh)	% of Lighting that is Appropriate for Occupancy Sensors	Lighting Energy Use that is affected by Occupancy Sensors.	Energy Savings based on Overall 10% Energy Use Reduction (kWh)
4,726,723	80%	3,781,378	378,137

Table 26 – Replacing 32W t-8s with 25W T-8s

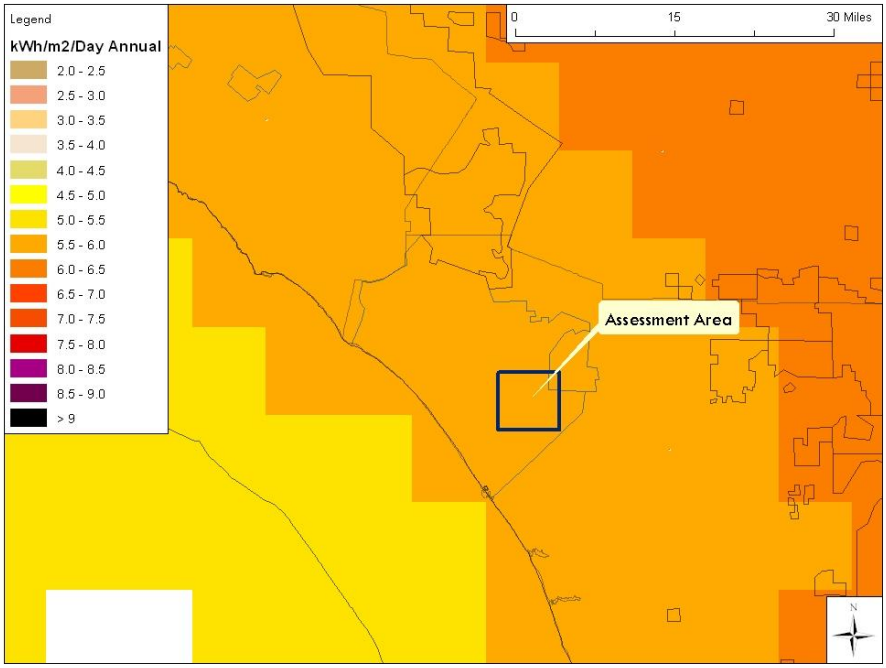
Total Area	Total kWh for lighting	Assumed % of Wattage that is Replaceable	Total Replaceable T-8 wattage	32W-25W % Reduction	Total Wattage Reduction	Energy Savings based on 21.88% Energy Use Reduction (kWh)
1,199,676	4,726,723	75.00%	3,545,042	21.88	775,655	775,655

Table 27 – Day-lighting for Unrefrigerated Warehouses

Total Sq. Footage	Warehouse EEI (kWh/ft^2-yr)	Total Lighting Usage	Estimated Reduction	Estimated Savings
778,672 ft^2	1.97	1533983.84	40%	613,593 kWh

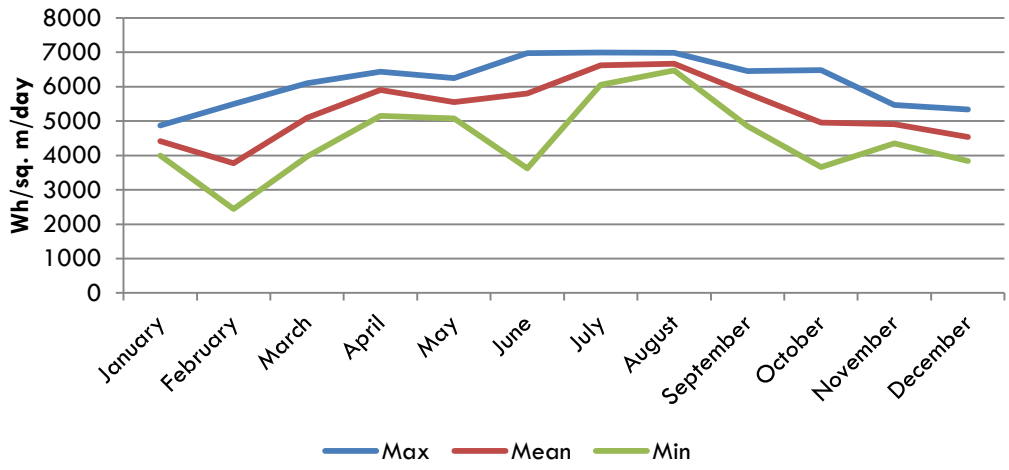
Appendix D: Renewable Energy Resource Map

Figure 16 – Photovoltaic Resource Map



Photovoltaic Solar Resource Map - This data provides monthly average and annual average daily total solar resource averaged over surface cells of 0.1 degrees in both latitude and longitude, or about 10 km in size. **Source:** Perez-SUNY/NREL, 2007 **Link:** http://www.nrel.gov/gis

Figure 17 – MCB Camp Pendleton Solar Resource Variability



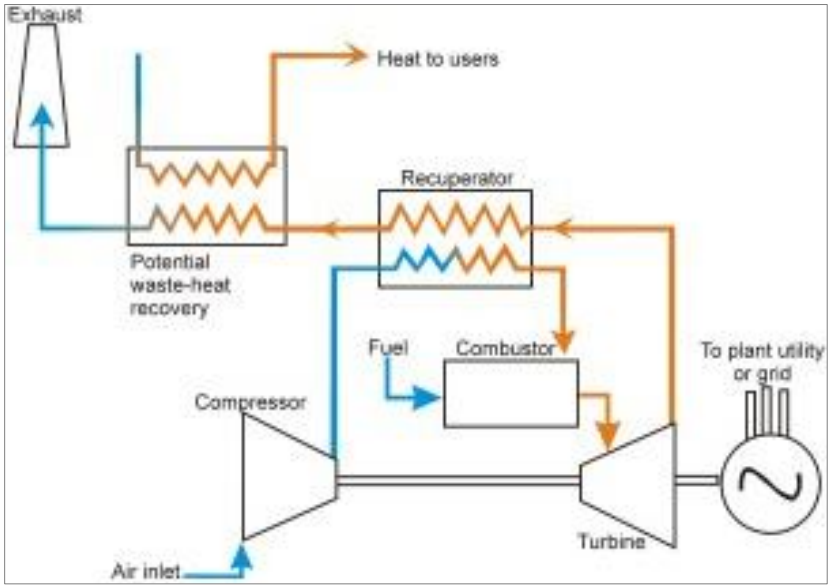
Source: Perez-SUNY/NREL, 2007 **Link:** http://www.nrel.gov/gis

Appendix E: Photovoltaic Projects and Micro-turbines

Table 28 – PV System Output

	50 kW System		25 kW System	
Month	**Output (kWh)**	**Value ($)**	**Output (kWh)**	**Value ($)**
January	5,107	$817.12	2,519	$403.04
February	4,421	$707.36	2,516	$402.56
March	6,270	$1,003.20	3,483	$557.28
April	7,372	$1,179.52	3,369	$539.04
May	6,401	$1,024.16	3,431	$548.96
June	5,783	$925.28	3,319	$531.04
July	6,563	$1,050.08	3,292	$526.72
August	6,387	$1,021.92	3,328	$532.48
September	6,693	$1,070.88	3,224	$515.84
October	5,683	$909.28	3,057	$489.12
November	5,574	$891.84	2,494	$399.04
December	4,823	$771.68	2,424	$387.84
Annual	**71,077**	**$11,372.32**	**36,456**	**$5,832.96**
Source: INBY Software Tool - NREL				

Figure 18 - Schematic of a Micro-turbine



Schematic of a micro-turbine Retrieved May 2, 2012, from http://www1.eere.energy.gov/manufacturing/distributedenergy/microturbines.html

Appendix F: DoD Energy Consumption 2010

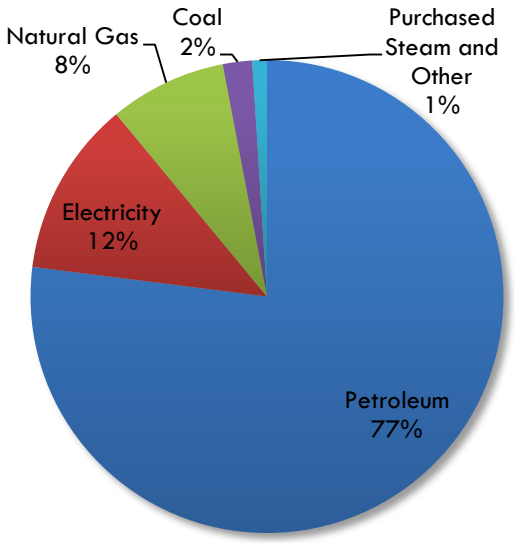
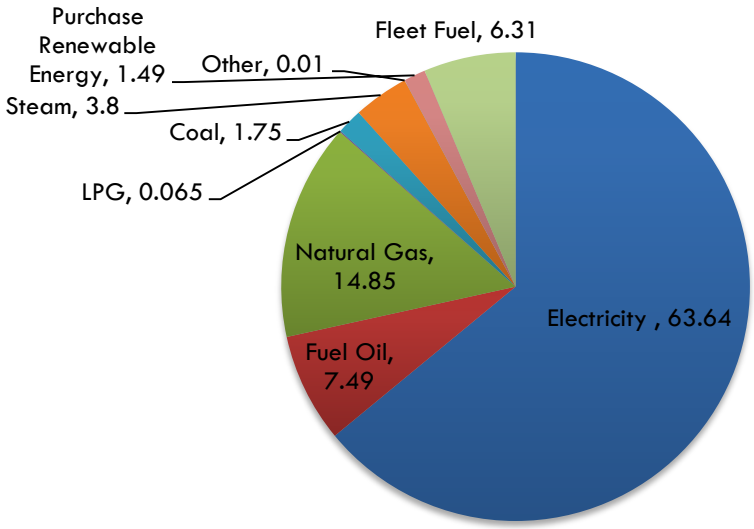


Figure 19 – DoD Energy Consumption

Figure 20 – DoD Installation Energy Use



Appendix G: Relevant Federal and DoD Mandates

Various legislation and an executive order require Federal agencies to reduce their natural resource consumption. This section presents a brief overview of the requirement for energy efficiency, renewable energy, and water conservation. This information was adapted from DOE EERE FEMP Laws and Regulations, Energy Independence & Security Act, http://www1.eere.energy.gov/femp/regulations/eisa.html

Energy Efficiency: The Energy Independence and Security Act of 2007 mandates energy efficiency improvements relative to a 2007 baseline. The required reduction is 3% per fiscal year between FY 2006 and FY 2015. The total reduction relative to the 2003 baseline should be 30%.

Water Conservation: Executive Order (E.O.) 13423 mandates a reduction in water consumption intensity (gallon/square foot) relative to a 2007 baseline. The required reduction is 2% per fiscal year between FY 2008 and FY 2015. The total reduction relative to the 2007 baseline should be by 16%.

Renewable Energy: EPAct 2005 mandates renewable usage in Federal facilities according to the following schedule: not less than 3% in FY 2007 to FY 2009, not less than 5% in FY 2010 to FY 2012, and not less than 7.5% in FY 2013 and thereafter.

E.O 13423 mandates that at least half of renewable energy used by the Federal Government must come from new renewable sources.

EISA 2007 requires 30% of the hot water demand in new Federal buildings (and major renovations) to be met with solar hot water equipment, provided it is life-cycle cost-effective.

DoD Mandates: The National Defense Authorization Act to 2007 requires the DoD to generate 25% of its electricity from renewable sources by 2025.

Appendix H: Building Details

Table 29 – Total Building Details

Building #	Building Type	Total Sq Ft.	Total Annual Usage (kWh)	Total Annual Usage MBTU	Total Cost per kWh	Total Cost per MBTU
2236	Unrefrigerated Warehouse	66,079	300,000	138.767	$ 48,900.00	$ 1,576.39
2234	Unrefrigerated Warehouse	64,543	293,024	135.540	$ 47,762.99	$ 1,539.73
2241	Small Office	63,612	771,619	133.586	$ 125,773.86	$ 1,517.54
2242	Unrefrigerated Warehouse	64,318	292,003	135.067	$ 47,596.41	$ 1,534.36
2251	Small Office	66,315	804,405	139.262	$ 131,118.01	$ 1,582.02
2243	Small Office	65,933	799,768	138.459	$ 130,362.15	$ 1,572.90
22048	Unrefrigerated Warehouse	6,470	29,372	13.586	$ 4,787.69	$ 154.34
2252	Small Office	64,910	787,357	136.311	$ 128,339.20	$ 1,548.49
2253	Unrefrigerated Warehouse	65,866	299,031	138.318	$ 48,742.10	$ 1,571.30
2261	Unrefrigerated Warehouse	66,993	304,147	140.685	$ 49,575.92	$ 1,598.18
2291	Small Office	45,230	548,641	94.983	$ 89,428.43	$ 1,079.01
2262	Unrefrigerated Warehouse	65,700	298,278	137.970	$ 48,619.25	$ 1,567.34
2263	Small Office	66,101	801,810	138.813	$ 130,695.03	$ 1,576.92
22101	Small Office	66,913	811,650	140.516	$ 132,298.95	$ 1,596.27
22113	Unrefrigerated Warehouse	66,856	303,527	140.398	$ 49,474.85	$ 1,594.92
22114	Unrefrigerated Warehouse	65,761	298,556	138.098	$ 48,664.56	$ 1,568.80
2264	Small Office	29,825	361,781	62.633	$ 58,970.25	$ 711.51
22151	Small Office	75,107	911,050	157.725	$ 148,501.11	$ 1,791.76
22207	Small Office	22,235	269,707	46.693	$ 43,962.31	$ 530.43
22206	Small Office	18,913	229,419	39.718	$ 37,395.31	$ 451.20
22209	Small Office	22,535	273,349	47.323	$ 44,555.92	$ 537.59
22212	Bachelor Enlisted Quarters	23,995	386,318	1,480.486	$ 62,969.86	$ 16,818.33
22210	Bachelor Enlisted Quarters	23,380	376,423	1,442.566	$ 61,356.99	$ 16,387.55
22211	Small Office	12,893	156,397	27.076	$ 25,492.78	$ 307.59
22172	Small Office	16,434	199,342	34.511	$ 32,492.76	$ 392.04
22065	School	31,613	211,492	221.292	$ 34,473.17	$ 2,513.88
2246	Small Office	66,895	811,436	140.479	$ 132,264.04	$ 1,595.85

2237	Small Office	62,592	759,240	131.443	$ 123,756.14	$ 1,493.19
2238	Small Office	65,822	798,424	138.227	$ 130,143.14	$ 1,570.26
2296	Small Office	65,026	788,764	136.554	$ 128,568.50	$ 1,551.26
22112	Unrefrigerated Warehouse	65,888	299,133	138.365	$ 48,758.66	$ 1,571.83
22111	Unrefrigerated Warehouse	66,067	299,945	138.741	$ 48,891.09	$ 1,576.10
22160	Health	16,273	307,878	992.631	$ 50,184.15	$ 11,276.28
220101A	Small Office	7,682	93,187	16.133	$ 15,189.52	$ 183.27
220101B	Small Office	7,535	91,402	15.824	$ 14,898.53	$ 179.76
220101C	Small Office	4,436	53,813	9.316	$ 8,771.51	$ 105.83
220101D	Small Office	7,476	90,688	15.700	$ 14,782.14	$ 178.36
220101E	Small Office	5,402	65,524	11.344	$ 10,680.38	$ 128.87
220101F	Small Office	5,730	69,508	12.034	$ 11,329.87	$ 136.70
22225	Unrefrigerated Warehouse	15,271	69,331	32.069	$ 11,300.90	$ 364.31
22220	Small Office	33,084	401,314	69.477	$ 65,414.23	$ 789.26
220110	Small Office	58,539	710,084	122.933	$ 115,743.71	$ 1,396.52
22053	Unrefrigerated Warehouse	3,529	16,024	7.412	$ 2,611.89	$ 84.20
22300	Unrefrigerated Warehouse	23,734	107,753	49.842	$ 17,563.77	$ 566.20
22187	Miscellaneous/Utility	11,051	107,417	137.034	$ 17,508.97	$ 1,556.71
2265	Small Office	34,987	424,398	73.474	$ 69,176.91	$ 834.66
22026	Restaurant	5,455	238,563	964.509	$ 38,885.82	$ 10,956.83
22105	Small Office	96,417	1,169,539	202.476	$ 190,634.90	$ 2,300.13
22141	Miscellaneous/Utility	4,649	45,190	57.650	$ 7,366.04	$ 654.91
220191	Bachelor Enlisted Quarters	13,647	219,724	842.049	$ 35,815.06	$ 9,565.68
220192	Small Office	13,280	161,092	27.889	$ 26,257.92	$ 316.82
220194	Bachelor Enlisted Quarters	9,826	158,196	606.253	$ 25,785.89	$ 6,887.03
220193	Bachelor Enlisted Quarters	11,739	188,994	724.280	$ 30,805.98	$ 8,227.83
22190	Health	32,369	612,421	1,974.508	$ 99,824.63	$ 22,430.41
22196	Retail	11,747	181,967	28.194	$ 29,660.62	$ 320.28
22186	Restaurant	37,859	459,233	79.504	$ 74,854.99	$ 903.17
22174	Restaurant	9,740	425,912	1,721.958	$ 69,423.65	$ 19,561.45
220166	Miscellaneous/Utility	2,390	23,231	29.637	$ 3,786.69	$ 336.67
2276	Small Office	9,955	120,751	20.905	$ 19,682.36	$ 237.48

22075	Miscellaneous/Utility	9,365	91,026	116.124	$ 14,837.29	$ 1,319.17
2271	Miscellaneous/Utility	11,013	107,048	136.564	$ 17,448.90	$ 1,551.37
22072	Miscellaneous/Utility	8,021	77,963	99.458	$ 12,707.89	$ 1,129.85
22213	Unrefrigerated Warehouse	7,197	32,675	15.114	$ 5,325.97	$ 171.69
22180	Small Office	12,243	148,506	25.710	$ 24,206.42	$ 292.07
22143	Small Office	5,615	68,106	11.791	$ 11,101.31	$ 133.94
22068	Miscellaneous/Utility	3,403	33,080	42.200	$ 5,391.99	$ 479.40
22124	Miscellaneous/Utility	12,854.35	124,944	159.394	$ 20,365.92	$ 1,810.72
2230	Unrefrigerated Warehouse	64,399.37	292,373	135.239	$ 47,656.82	$ 1,536.31

Appendix I: PV Project Glossary

Size: This size represents the DC PV size in kW that is used to calculate the rebates, tax-credits, costs, and payback.

Rebates: The rebates used here are taken from the Database of State Incentives for Renewables & Efficiency (DSIRE)

Tax Credit: Each tax-credit for your location is selected from the Database of State Incentives for Renewables & Efficiency (DSIRE) and is aggregated to present one value here. This value includes local, state, and Federal tax credits.

PV Cost: This values presents a general estimate of the cost of installing PV. The value is dollars per watt ($/W), and is computed from a list of known PV installations and their cost.

Initial Cost: The initial cost represents the initial total cost one would pay for this PV installation. This value is computed by multiplying the size of a PV system with the cost per watt defined above.

Cost After Incentives: The "cost after incentives" represents the subtraction of the selected PV incentives from the initial cost of the system.

Payback: This value estimates the number of years it might take to recoup the cost of this PV system. This value considers the general operating and maintenance costs and the annual electricity production of the PV system to determine the number of years until enough money is made from the system to equal the initial system cost. However, this value does not consider the amount of monthly electric bill savings one may find from this PV system.

Energy Glossary

British Thermal Unit (BTU)	The standard unit for measuring quantity of heat energy. It is the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit.
MMBtu:	one million (10^6) British thermal units
Watt (W):	The unit of electrical power equal to one ampere under a pressure of one volt. A Watt is equal to 1/746 horse power.
Kilowatt-Hour (kWh)	The basic unit of electric energy equal to one kilowatt of power supplied to or taken from an electric circuit for one hour
Source: SDG&E	

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
May 7th 2012	Professional Report	

4. TITLE AND SUBTITLE

Energy Reduction Strategies for
Marine Corps Base Camp Pendleton
Assessment and Recommendations

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Gregory Charles Wiley

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of California, Irvine

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Professor Tim-Allen Bruckner
Department of Planning, Policy, and Design
University of California, Irvine

10. SPONSOR/MONITOR'S ACRONYM(S)

UC Irvine

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*

The purpose of this report is to identify actions to reduce the energy consumption of existing buildings at the Marine Corps Base Camp Pendleton in California and to provide recommendations for the implementation of these actions. The assessment begins with a baseline assessment of current electrical and natural gas consumption. Energy conservation and efficiency projects are explored to identify economic approaches to minimizing Base energy demand. Renewable energy technologies are then examined for their potential for energy reduction. This assessment leads to recommendations for further energy conservation, energy efficiency measures, and renewable energy reduction projects.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Gregory Wiley
Unclassified	Unclassified	Unclassified	UL		19b. TELEPHONE NUMBER (*Include area code*) 805-895-9511